Climate change and human security in the Reef Islands: A study from the easternmost parts of Solomon Islands

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Publication date:
2010

Document version
Early version, also known as pre-print

Citation for published version (APA):
Birk, T. L. K. (2010). *Climate change and human security in the Reef Islands: A study from the easternmost parts of Solomon Islands*. (pp. 1-39).

Research report – preliminary findings, 2010

Climate change and human security in the Reef Islands

A study from the easternmost parts of Solomon Islands

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Important note

The findings presented in this report are preliminary results from field research in the Reef Islands, Solomon Islands Sept/Oct 2009 & Feb/March 2010. The report was compiled to provide rapid feedback to stakeholders at all levels, particularly Solomon Islands national Climate Change Division (CCD). At this stage, the results have not been subject to detailed analysis.

The research conducted in Solomon Islands forms part of a 3-year PhD-program (2009-2012) at the Department of Geography and Geology, University of Copenhagen, Denmark. In due course, additional findings and research results will be communicated through international scientific journals and conferences. Softcopies will be forwarded to the Climate Change Division and focal point at Ministry of Environment, Meteorology and Conservation, Honiara. Please contact the author for more information.

Although a draft of this report was reviewed by the national Climate Change Division (CCD), the Ministry of Environment, Conservation and Meteorology (MECM), the author holds full responsibility for any shortcomings or errors in this final version. It has been an intention to balance the input from 'accepted scientific knowledge' with insights gained throughout the stay in Reef Islands, including the valuable knowledge gained from conversations with the people of Reef Islands. Throughout the report, the voices of Reef Islanders have not been explicitly distinguished from the voice of the author. Hence, the ideas presented here must not be confused with those of local stakeholders and interviewees – they are not to hold responsible for the views in the report, except that they have a stake in the potential outcome. Even so, I hope the report will provide input for discussion, further studies or project planning and implementation.

Acknowledgements

I would like to thank the Premier of Temotu Province, Hon. Edward Daiwo for his endorsement of the research proposal, and the Ministry of Education and Human Resource Development for research permits. Moreover, I wish to express my gratitude to the Ministry of Environment, Conservation and Meteorology for their support during my stay (advice, support letters, desk space etc.); particular thanks goes to Under Secretary Chanel Iroi, as well as the Director and Deputy director of the Climate Change Division, Douglas Yee and Hudson Kaihioana for their support and friendship.

At last, but not least, I wish to acknowledge the people of the Reef Islands and thank them for sharing their knowledge, time and beautiful islands with me during my stay. Special thanks goes to Jacob Tebby, Martin Palusi, James Tavake, Hon. John Paia, Ben Hepworth and the people of Tanga village in Fenualoa Island - **awi!**

This research was funded by the by the Faculty of Science, University of Copenhagen, Denmark. Enquiries about the research can be directed to:

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Summary

In Solomon Islands climate variability and change are often associated with significant risks for people and their livelihoods. On a regional scale, the observed and projected climate changes and associated effects include rising temperatures; alteration of rainfall patterns; increased intensity of extreme events (e.g. cyclones); accelerated sea level rise; and warming and acidification of sea surface layers. These changes have been perceived as risk multipliers exacerbating environmental and socio-economic challenges already faced by many Solomon Islanders. Thus, climate variability and change represents a concern relevant to all levels of society, i.e. national decision-makers; provincial governments; local communities as well as individual households. However, Solomon Islands is a country that consists of multiple islands and communities, which are neither evenly exposed to climate variability and change, nor equally capable of adapting to climate related challenges. Within societies, different types of climate change is likely to bring opportunities to some people and increased vulnerability to others, especially those who are already marginalized (Tompkins and Adger, 2004). Hence, it is important to recognize that climate change vulnerability and adaptation is context specific to people and places (Adger *et al.* 2007; Rasmussen *et al.* 2009).

This report gives attention to atolls and low-lying reef islands in remote parts of the country, with particular focus on the Reef Islands in Temotu Province[1]. In these places, sea-level rise, storm surges and coastal erosion as an effect of climate change have become a particular concern, since the inhabitants already face the challenge of tackling ongoing coastal erosion and partial inundation. These effects could become more pronounced in the coming decades as a consequence of rising sea levels. Moreover, the long term projections proposing a future situation with sea stands around 0.8 m above current levels by the end of the 21st century (Fussel, 2009), have led to more drastic scenarios for atoll living (Dickinson, 2009). It has recently been questioned to what extent local adaptation in Solomon Islands atoll's is realistic at reasonable costs and whether or not these islands will be able to sustain human habitation in a not to far future (SI Parliament, 2009; Rasmussen *et al.* 2011).

Solomon Islands government has identified low-lying reef and atoll islands as a high priority in the National Adaptation Programmes of Action. By referring to long term sea level projections, it has been proposed that relocation of communities is the only option of adaptation. This message was reemphasized during a parliament debate in April 2009 by several of its members (MECM, 2008; SI Parliament, 2009).

Drawing on field work and consultations with local people in the Reef Islands, this report reflects on a range of key vulnerabilities in the Reef Islands. Accordingly, it proposes a series of adaptation options, which possibly could reduce the immediate exposure and sensitivity to climate variability and change. Due to the large uncertainties associated with climate projections, it has been a priority to focus on adaptive options that do not solely reduce potential or hypothetical risks, but essentially consider the known effects of weather extremes, climate variability and natural hazards (i.e. disaster risk management) as well as the challenges related to a broader notion of sustainable development (e.g. Millennium Development Goals). In conclusion, the report suggests that national adaptation policies are more likely to succeed if they are based on consultations and proper involvement of local communities at an early stage in the process. Moreover, uncertainties associated with predicting long term changes and impacts are substantial; therefore it is recommended to prioritize immediate needs and wants over hypothetical threats.

[1] The author has previously conducted field work in Ontong Java atoll, as part of the CLIP research project 2006-2007 (CLIP, 2007). However, the findings in this report are not directly applicable to Luaniua and Pelau Islands (Ontong Java), although some of the vulnerability characteristics and options for adaptation are similar. Likewise, findings should be cautiously applied to Sikaiana atoll or elsewhere

1. Climate change, vulnerability and adaptation

As a small island developing state (SIDS), Solomon Islands has been categorized as a country that is particularly vulnerable to the effects of climate variability and change (Mimura *et al.* 2007). Like many other Pacific island countries, Solomon Islands is often described as financially fragile and politically unstable, resulting in low scores on the Human Development Index (UNDP, 2010). It is widely accepted that these are parameters influencing the capacity to adapt to the effects of climate variability and change. While this may be the case of Solomon Islands, it is also worth to recognize the richness and complexity of the country as a whole, reflected in the plurality of its geographical characteristics and cultural diversity.

Solomon Islands is composed of multiple and different types of islands scattered over a large geographic area. The exposure and sensitivity to climate variability and change, as well as the occurrence of extreme weather events vary across the country region. As an example, communities living in high volcanic islands are less exposed to storm surges and flooding from the sea than those inhabiting low-lying atoll islands, although the former may then be at higher risk of erosion caused by heavy precipitation.

Recognition the island-to-island difference implies that adaptation needs and wants are often specific to people and places. This report addresses the challenge associated with climate variability and change in low-lying atoll and reef islands, with a particular focus on the group of islands known as "the Reef Islands", which are located about 60 km north of Ndeni / Santa Cruz Island in the easternmost Temotu province. Consequently, the findings from this study are case-specific and therefore do not necessarily apply to other islands in the Solomons or elsewhere.

1.1. Climate and climate change

The **climate** in Solomon Islands is characterised by high and rather uniform temperature and humidity, as typical of many tropical areas. In terms of documentation, there are relatively few weather stations across the country, which makes it difficult to distinguish the variations within island groups and provinces. With regards to the Reef Islands, the nearest weather station is situated in the provincial capital Lata on the mountainous Ndeni Island. However, since Lata is situated close by the sea, the temperature and humidity varies only slightly throughout the year and nearly reflects the national mean temperature which is 27° Celsius.

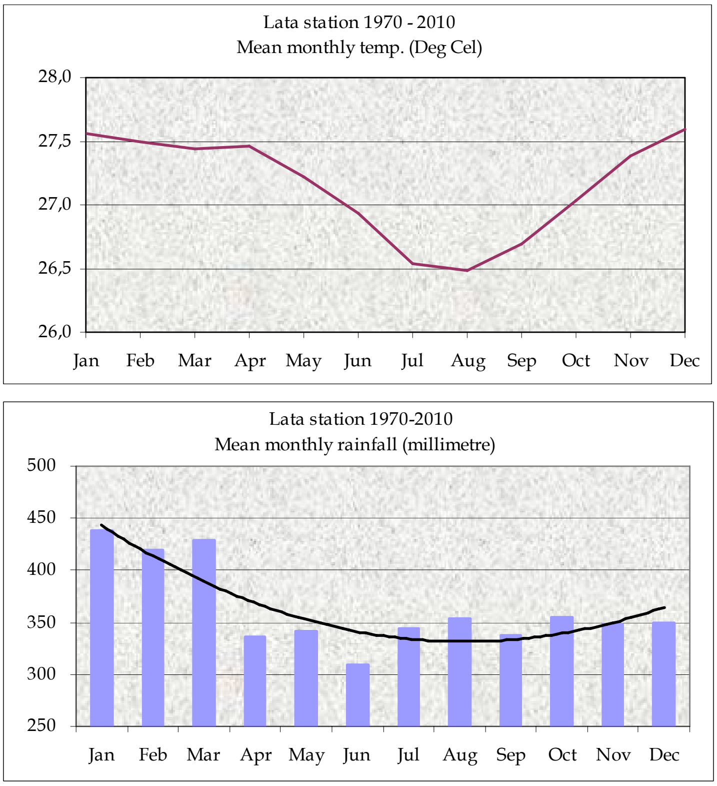
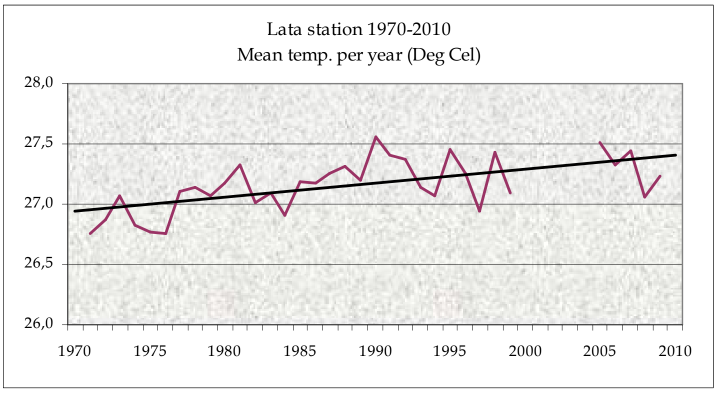


Fig 1: The top figure shows the monthly mean temperatures, while the lower figure shows monthly mean rainfall. Both figures are based on data from Solomon Islands Meteorological Service.

Compared to temperature and humidity, the precipitation pattern across the country is less uniform, with topographical effects causing significant variations within and difference between locations. In general, yearly rainfall in most parts of the country range between 3000 and 5000 mm. In Lata rainfall is about 4300 mm/yr based on a 40 year period, with a minimum of 3200 mm/yr in 1992 and a maximum of 5700 mm/yr in 1999.

Wind and precipitation patterns are generally influenced by the seasonal variation in the location of the South Pacific Convergence Zone (SPCZ). Thus, the period from May to October is characterised by East to Southeast winds, while less persistent West to Northwest winds blow from November to April. The latter period is characterised by occasional strong winds and tropical cyclones, and is also referred to as the 'wet season' with more cloud formations and higher precipitation levels. In the Reef Islands the strong western winds often have negative effects on fruit crops (banana, bread fruit, coconuts), which are blown off the trees. Likewise, strong western winds are often a nuisance to people, since it damages buildings and other material, and constrain people from key livelihood activities such as fishing and boat travelling. The occasional low pressure systems and cyclone winds usually cause serious damages to trees, buildings, people, livestock and coral reef. Nonetheless, while the short term effects of strong winds and cyclones are rather destructive, the medium to long term effects of such high-magnitude events on reef and atoll islands may be seen as constructive and quite essential for the replenishment of sediment on shorelines[2].

On a national scale, the frequency of cyclones is about 1-2 every year, but some islands lie outside the typical cyclone track. In general tropical cyclones rarely form or move within 5-6 degrees or 550-600 km of the equator. In recent decades, Temotu province has experienced a few highly intense cyclones, e.g. cyclone Zoe in late 2002 and cyclone Nina at New Year 1992/3. Tikopia suffered the worst damage from cyclone Zoe, while Nina caused strong impacts on several islands, including the Reef Islands.



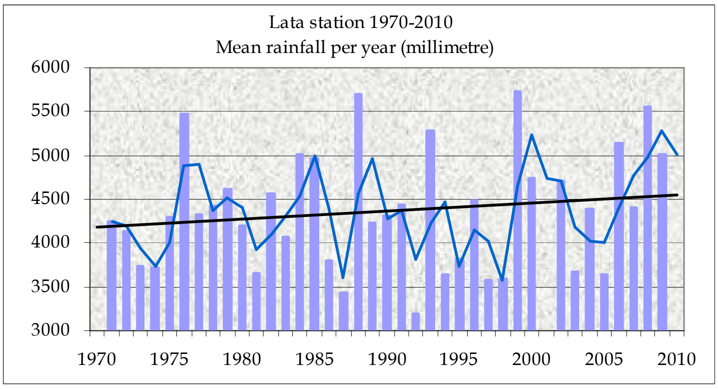


Fig 2: The top figure illustrates changes in yearly mean temperature, while the lower figure shows yearly mean rainfall. An added linear trend line indicates a slight increase in temperature and rainfall over the 40-year period. However, the data also reveals large interannual variability, impliying that linear interpretation should be applied with caution. The figures are based on raw data from Solomon Islands Meteorological Service.

Extended dry spells and droughts occur almost every year, but are usually more pronounced during El Niño years (every 3-7 years)[3]. In many parts of the country, the period from June through July and August is

[2] Bayliss-Smith (1988) demonstrated the 'constructive' long-term effects of cyclone Annie on shorelines in Ontong Java, where rubble ramparts thrown up by the hurricane had been largely reworked into stable landforms, mainly through the agency of more frequent, lower-magnitude storms.

[3] El Niño or El Niño Southern Oscillation is characterised by prolonged differences in ocean surface temperature across the Pacific causing increased precipitation in the east, while precipitation is reduced in the west.

referred to as the 'dry season', but with regards to detrimental effects on crop production and water supply this is rather place specific depending on soil quality, topography and access to fresh water resources.

The UN climate panel (IPCC) advises that **climate change** in the South Pacific region and Solomon Islands region in general reflects the trends observed on a global scale, with data showing that mean temperatures gradually increases. Although the exact regional and local effects of these temperature changes are difficult to estimate, detectable changes in precipitation patterns and temperature extremes have been reported. As example, the Intergovernmental Panel of Climate Change (IPCC)[4] report a slight increase in precipitation (4 %) over the oceans in the latitude range 25°N to 25°S, although there are significant deviations between adjacent areas. In general the warming of the lower parts of the atmosphere is followed by increased evaporation of water from the ocean surface, which may lead to an increase in cloud formation and precipitation levels. Based on the data presented in figure 2, illustrating yearly rainfall measurements from Lata in Temotu Province, the applied linear trend line indicates a slight increase in rainfall over the 40 year period, although it also shows great variability over the years. However, whether these data proves an actual change in precipitation for the Temotu region is uncertain, since the measurement is limited to one spot and therefore do not account for spatial variations within the region. Apparently, Solomon Islands meteorological service have calculated dissimilar trends for Temotu and the rest of the Solomons, indicating quite significant decrease in rainfall, while temperatures on the other hand are increasing.

Even though graphs and figures are often useful to illustrate changes, they should be interpreted with caution, especially as a basis for projecting the future. As such, the figures shown above serve best to indicate the large interannual variations of temperatures and rainfall, implying that gradual changes are not easily detected. As described earlier, rainfall varies a lot within and between islands; thus, variations at a single location can be as much as 2000 mm from one year to the next (e.g. 1987/88 & 1998/99).

For the whole of Solomon Islands, the work of the national meteorology service is hampered by the lack of data and insufficient human resources and proper equipment for handling the data that are collected. As a result, the government has had to base most of its country-wide review on second-hand information, such as the IPCC regional assessment reports. However, as described earlier, the data from the few weather stations around the country have been introduced in some national reports, to support the regional and global warming trends (MCTA, 2001; MECM, 2008).

1.1.1 Climate change projections

With regards to future changes in temperatures and precipitation for Solomon Islands region, the IPCC projects a temperature increase of about 0.5-1.0 °C before year 2050. On a longer time scale, temperatures are likely to increase even more, depending on the trajectory of global emission reductions, new technologies and willingness to change behaviour. For the South Pacific region in general, the projections for precipitation reveal a high degree of uncertainty, since they point towards both an increase and decrease of rainfall within the region as a whole. Thus, some parts of the region might experience a 5 % increase in yearly rainfall over the next 30-40 years, while other parts might experience a 5 % decrease. Long term projections show a further increase or decrease in correspondence with these trends.

[4] IPCC is a panel or group of distinguished researchers reviewing and summarizing findings from the latest research on climate change related matters. The latest report from the IPCC was published in 2007, but the findings in the report is based on pre-2005 data. See www.ipcc.ch for more information

Although the climate system is complex, with a lot of interlinking components, heat is one of the main driver of changes. Thus, temperature changes will also influence other weather phenomena, such as tropical storms, cyclones and droughts. Together with heavy rainfall and floods, these are often referred to as extreme events. The IPCC suggests that some of these events are likely to become more frequent and intense as temperatures increases. In some regions of the world, an increased frequency of high intensity cyclones has been recorded over the last couple of decades. Again, based on the national observations, it is very hard to detect if these changes can be observed in the Solomon due to the lack of data.

Temperature increase is also affecting the level of the world's oceans, as a result of 1) the melting of glaziers or inland ice, which means that more fresh water runs into the sea, and 2) because temperature increase in the upper layers of the ocean increase the volume of the water – often referred to as thermal expansion. Once again, there is a lack of historical records showing the changes in sea level in the South Pacific, although there is some evidence showing an increase of about 2 mm/yr since 1950, which is close to the global average (Church *et al.* 2006). In terms of projections for the future, there has been much speculation about the contribution from melting glaciers. Recently published scientific evidence suggests that the rate of sea level rise is accelerating and that the most likely estimate is an increase between 0.5 to 0.9 meter, or even more by the end of the 21st century (E.g. Rahmstorf, 2007; Dickinson, 2009; Fussel, 2009). However, these are global average estimates, and there are likely to be considerable regional variances in sea level rise across the Pacific. In Solomon Islands, there is no official baseline for mean sea level, which means that changes are difficult to monitor on-ground. The tidal gauge in Honiara represents the only known site of controlled measurements of sea level change, implying that output data cannot be validated or compared with other sites. Hence, it is difficult to single out the long term changes in sea from variability and tectonic effects. Despite large uncertainties involved in such estimates, the possibility of 'worst-case' scenarios needs to be considered when planning long term adaptation measures, especially in coastal areas and low-lying islands. The possible need and consequences of relocation is considered in section 3.3.1

1.1.2 People's perceptions and access to information

Temperature and sea level changes are easily tracked by the use of modern measuring equipment; then processed and illustrated as graphs or tables by the use of basic computer software. However, minuscule changes in mean climate conditions may be rather difficult for 'ordinary' people on the ground to sense or even grasp. Although the concepts of climate change or 'global warming' imply that the world is getting warmer, the changes are quite subtle and slow after all. Moreover the scientific reports refer to changes taking place on a global level, which may be difficult to grasp without basic knowledge of the linkages between global, regional and local climate systems. Therefore, in Reef Islands and elsewhere in the Solomons people's perception of climate change often reflect the ways in which changes manifest themselves in their immediate surroundings and/or are consolidated through information or awareness campaigns (newspapers, radio etc.). Everyone talks about the weather, and experience with seasonality and weather patterns is an inherent part of local ecological knowledge in all parts of Solomon Islands. Although this knowledge or 'data' are rarely written down or registered, there is a good public understanding about various signs indicating changes in the weather. This kind of knowledge is often passed down by the communities' elder members or skillful individuals (e.g. navigators, farmers, fishermen etc.). Although local knowledge about weather patterns and seasonality do not necessarily provide the same kind of accuracy as meteorological measurements, it would be motivating to see more of this local 'wisdom' acknowledged as a supplement to scientific measurements or top-down assessments, and maybe organized in ways that makes it easier available for central decisions-makers and planners.

There are a number of reasons to be cautious about the use of the 'common' and accepted climate change scenarios, particularly when it comes to downscaling in order to forecast the impacts of changes in a context-specific and local setting. Scenarios represent conditional projections based on specific assumptions, which means that they should not be mistaken as predictions or prophesies. As an example, climate change scenarios and projections primarily use numerical data, which is easier to test or compute than the insights from social science about human behavior. Hence, although the scenarios largely reflect the current understanding of human-environmental systems, it has been difficult to incorporate much of the documented 'soft' data, including the adaptive behavior and response strategies employed by local communities under changing environmental conditions

1.2. Social-economic and environmental changes

Although Solomon Islands has experienced significant economic growth in the last decades, the country is still ranked low according to international wealth standards[5]. The country relies on overseas development aid (ODA), which has been supporting the national economy and security, as well as many projects aiming at the improvement of key sectors such as education and healthcare. Much of this activity has taken place in urban areas, particularly Honiara and larger towns in the main islands. Clearly, the scattered nature of the country's multiple islands hampers the redistribution of financial resources and government services to rural communities. While many efforts have been aiming at the improvement of rural development and to decentralize decision-making, the perceived disparity and inequality between the rural and urban population in terms of income and political influence is rising.

Apart from development aid, the Solomon Islands economy is largely based on natural resource extraction, including timber, marine resources, fishing licences and agricultural products (e.g. cocoa and copra). The large rainforests and rich waters in Solomon Islands have great potential for the country's economy if managed sustainably, but there has been great concern about the business procedures practiced by both foreign and domestic companies, and a widespread worry about the heavy exploitation and accelerated decline of natural forests areas and marine life. The government benefits from the taxation of resource extraction, but a significant percentage of the revenues are harvested by foreign investors and domestic land owners.

Solomon Islands country facts:
Pop. size: ~ 550.000 (estimate July 2010)
Pop. growth rate: 2,3 %
GDP: US$ 675 million (estimate 2009)
GDP per capita: US$ 1,125 (calc.)
Land area: 28,896 sq km
Pop. density: ~20 per sq km
Human Development Index: 0.494 (2010)

Fig 3: Key country facts

The independent organization 'Transparency International' have placed Solomon Islands remarkably low on their index, indicating that the country has a serious corruption problem (Riaño *et al.* 2010). Apparently, this does not come as a surprise to the groups of people in Solomon Islands who have been consulted by the same organization about their perception of corruption in the country. The majorities of Solomon Islanders are aware that corruption is taking place at all levels in society, but tend to express their mistrust in public institutions and policy makers. Although this view may be valid, the public concern is also driven by perceived inequalities of economic opportunities within the country. For many reasons, the market

[5] Solomon Islands is categorized by the UN as a least developed country (LDC) of which there are currently 49 in the world. According to the United Nations, LDC's exhibits the lowest indicators of socioeconomic development, with the lowest Human Development Index ratings of all countries in the world.

oriented economic development in the country has been schewed towards the town areas, while rural wealth continues to lie in the access to natural resources. Post-independence and globalization processes have caused a rapid change in existent and anticipated living standards, including a higher dependency on the import of commodities and expectations of government welfare. The geographical disadvantages of remote rural populations are obvious in terms of transport costs, creating barriers for local economic development and hampering their participation in central decision-making processes.

Altogether, these factors increase the obstacles of reducing rural poverty and human insecurity, even when it comes to satisfying basic needs such as clean water, shelter, food, education and health services. Poverty constrains people's capacity to deal with socio-economic stressors (e.g. political instability, social conflicts, and price fluctuations) and environmental perturbations, including the effects of climate variability and weather extremes. On a national scale, the nature of economic and political disparity within the country supports the view that adaptive capacity and practical adaptation is very context-specific. People's access to resources (economic, social and natural) and their influence on decision-making to a large extent determines their ability to cope with and adapt to environmental and socio-economic stressors, including climate variability and change (Adger *et al.* 2007; Adger *et al.* 2003; Brooks *et al.* 2005; Kelly and Adger, 2000).

Admittedly, in a country like Solomon Islands, wealth and adaptive capacity cannot solely be defined in monetary terms, since people rely on many other assets to sustain their livelihoods. Human resources and social networks in form of kinship and community relations are extremely important in times of crisis, when people rely on extended families or relatives living nearby or elsewhere (e.g. in Honiara). Remittances are an extremely important element of the extended household arrangements characterizing the complex socio-economic systems of communities in Solomon Islands and other Pacific nations (Connell and Brown, 2005). In Solomon Islands most of the remittances come from family members migrating temporarily to Honiara or other urban centers to find employment. It could be argued that the combination of internal labor migration and remittance (i.e. money, food and other goods) represent the most important coping strategy in times of crisis, since it is often the main (sometimes only) source of financial income for families in remote rural areas (e.g. Rasmussen *et al.* 2009; Christensen and Gough, 2010; Rasmussen *et al.* 2011). Apart from social networks, the local biophysical environment is extremely important in determining people's access to important resources and in providing safety and shelter. Local adaptive capacity may be strengthened by the improved access to financial resources, but such improvements will always take place in a context of social, human, environmental assets/capitals (see methodology). In its aim for cost-efficient adaptation and 'no-regrets' solutions, the government should not mistake conventional economic assets as the only input to the equation, but also needs to consider non-economic assets.

Hence, various factors are important in determining human security and adaptive capacity at local and national level. People's access to public services such as hospitals, schools, information, jobs or market places differ greatly among communities in various parts of the country. Thus, communities located in remote distance from provincial centers or Honiara are often more restricted in their access to such public goods, than city dwellers are. The extension of certain services and institutions have slightly improved this disadvantage, but the government struggle to deliver the same quality of service to all regions, e.g. materials and qualified personnel for schools, medical centers, police quarters etc. Instead, the task of maintaining services in rural areas and sustaining development has to some extent been lifted by foreign aid and development organizations. However, not all 'public goods' are centered in urban areas, since life in the rural areas often includes better access to natural resources. Among the assets appreciated by rural dwellers; the access to land and sea is often highlighted along with peace and security, as provided by community structures and customary institutions.

While market oriented economic activities primarily take place in urban centers, the majority of the population still lives in rural areas. Therefore, the majority of communities and households largely rely on subsistence economies, where proper access to productive fishing grounds and gardening areas constitute vital elements in people's livelihoods. Apart from a small number of government paid jobs (e.g. teachers, nurses), households engage in small-scale businesses and/or trading of cash-crops (copra, cocoa, nuts etc.) and marine products (fish, shells, beche de mer etc.). However, cash has increasingly become a necessary means in household economies for the attainment of improved living standards and to satisfy individual wants, and has largely replaced traditional capital (feather money, food exchange, local crafts). As an example, the import of food and commodities is gradually increasing, and used to supplement or replace local production (e.g. rice, noodles, tobacco, tools etc.). Often, the limited income gained by households is often spent on immediate needs such as food or basic goods (clothes, fuel, fishing gear etc.), whereas only a few individuals manage to (and have a talent to) invest in private enterprises – and to be fortunate enough of creating a steady income by doing so.

Another important social-economic factor that influences development in Solomon Islands is population growth, which may be seen as a barrier of sustainable development; i.e. higher population densities lead to increased pressure on resources, which again lead to environmental degradation and increased food insecurity. While this hypothesis has been disputed, there is currently a good correlation in some parts of Solomon Islands between the increase of population densities and soil degradation. In the Reef Islands, fallow periods have been reduced considerably, from 5-7 years to 1-3 years in some cases. Hence, new strategies of agricultural management have to be considered in order to sustain the fertility and productivity in garden areas, and to meet the demands of a growing population. Additionally, it would be salient to address high population densities and growth rates, which is currently 2-3 % p.a., through proper land allocation and education. Currently, some work is being done by development organizations to create awareness about family planning and the use of contraceptives.

The social and economic issues introduced above serve to illustrate the manifold factors which affect the context and location specific sensitivity to climate change and the capacity to adapt, including adaptation barriers and opportunities. This report attempts to zoom in on these issues in a Reef Islands context. However, despite the best intentions, any community *assessment profile* is inclined to present a static image of local processes and dynamics. Hence, the report might be subject to competing interpretations and become in dire need of updates. Communities and people constantly move, develop and change, and so does the environment.

2. Methodology in brief

This report draws on field work in the Reef Islands in Sept/Oct 2009 and Feb/March 2010. Information from the reef Islands has mainly been gathered through focus group and stakeholder interviews, questionnaires and participatory observation. The methodological approach builds on a broad range of vulnerability, adaptation and development literature (E.g. Rasmussen *et al.* 2009; O'Brien *et al.* 2008; Adger *et al.* 2007; Adger *et al.* 2005; Thomas *et al.* 2005; Tompkins and Adger, 2004). However, in the assessment of vulnerability and adaptive capacity, the conceptual framework known as the 'sustainable livelihoods framework' provided useful guidelines for the structuring of questionnaires, interviews and mental maps (Chambers and Conway, 1992; Scoones, 1998).

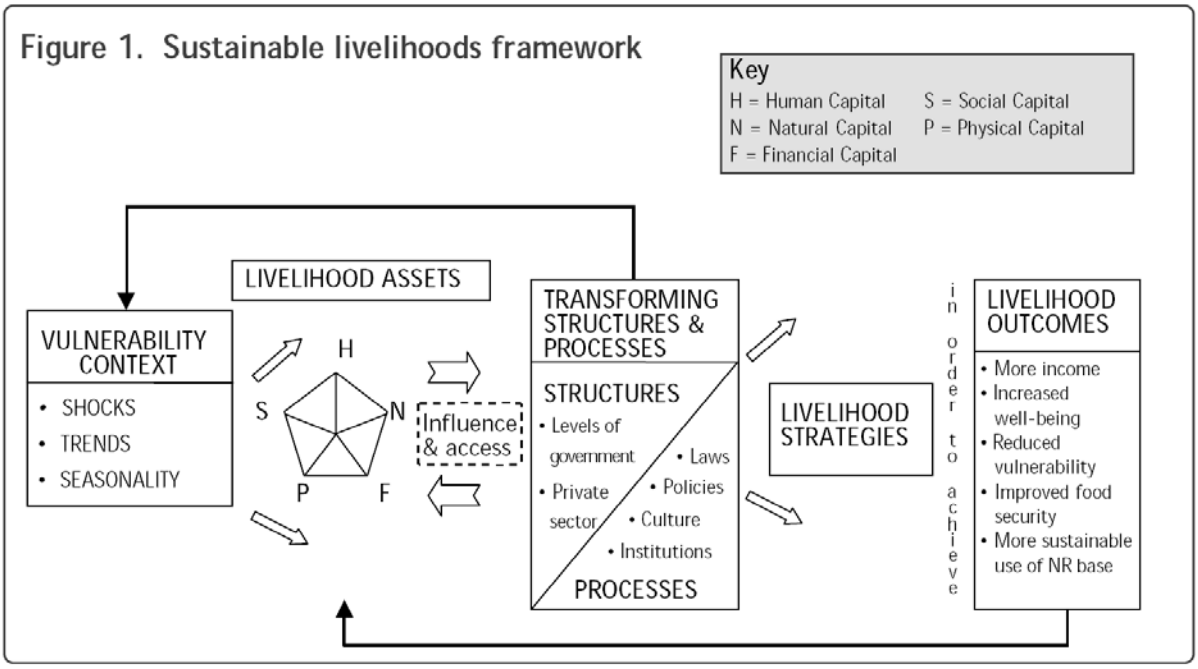


Fig 4: The sustainable livelihoods framework. Adopted from DFIDs guidance sheets, Department of International Development

The *sustainable livelihoods framework*, as illustrated by the figure above, describes the main factors that affect people's livelihoods, and typical relationships between these. In general the framework: 1) provides a checklist of important issues; and 2) draws attention to core influences and processes; and 3) put emphasis on the multiple linkages and interactions between the various factors which affect livelihoods. The framework is centred on people, who are represented in the figure by the pentagon. The five letters H, N, F, P and S refer to different assets or dimension of peoples livelihoods: H = *Human Assets*; N = *Natural assets*; F = *Financial assets*; P = *Physical assets*; S = *Social assets*. See examples of these assets in annex 1

In addition to the information gathered in the Reef Islands, important information has been obtained through a review of policy documents, assessment reports and consultations with relevant stakeholders in Lata and Honiara.

3. The Reef Islands: climate changes and challenges

This chapter describes some of the important changes and challenges influencing climate change vulnerability and adaptive capacity in the Reef Islands. The chapter is divided into three sections; the first part briefly describes the ***vulnerability profile*** or *adaptation context* at a local level, i.e. an introduction to the environmental and social circumstances in the Reef Islands. The second part - the ***diagnostic phase*** - identifies some of the risks associated with climate variability and change, whereas the third part discusses current and potential adaptation options. The last part is commonly referred to as an ***adaptation assessment*** or *evaluation*.

Overall, the chapter mainly deals with local circumstances and less with policy frameworks that could link local and national level. Currently, the work of mainstreaming of adaptation into national policies will be undertaken as part of the Pacific Adaptation to Climate Change project (PACC), which is still in the implementation phase (SPREP, 2007). In Solomon Islands, the PACC project actually focuses on the low-lying islands of Ontong Java, Sikaiana and the Reef Islands. This report therefore provides supplementary information in the PACC preparation and implementation process.

3.1. Adaptation context

Temotu province, previously known as the Santa Cruz Islands, is located in the most eastern part of Solomon Islands and is the second-least populated province[6] with only about 24,000 people inhabiting the 7 main islands / island groups. As in the rest of Solomon Islands the population is predominantly Melanesian, but the ratio of native Papuans and Polynesian speaking island communities is significantly larger than elsewhere. there are three groups of native Papuans in the Santa Cruz and Reef Islands, while the inhabitants of Tikopia, Anuta, the Duff Islands and five of the Reef Islands are inhabited by Polynesian speaking communities. According to a national household income and expenditure survey from 2005/6, Temotu province is the poorest in the country[7]. Although the survey does not offer any clarification on the drivers of poverty, the remote location of Temotu and the scattered nature of the island group is surely part of the explanation.

The uneasy access to markets is exacerbated by high transport costs and a rather poorly developed infrastructure, which evidently constrains income opportunities, particularly in the smaller and more isolated islands of the province. Temotu is located in a more remote and isolated setting that any other province in the country; closer to the northern parts of Vanuatu (island state) than to the neighboring province, Makira and Ulawa. Flight connections between Honiara and Lata are frequent, which makes it easy for those that can afford the fairly expensive tickets (SBD $1.500-2.000 one way), while the less frequent and irregular boat connections are the preferred choice of people travelling between Temotu and Honiara (SBD $400-500 one way). Apart from the irregular ‘ferry’ that connects the islands of Temotu with the world beyond, the transportation to and between the smaller islands is often both a complicated, lengthy and risky exercise. Until 20-30 years ago, the journey was done by the use of hand-driven canoes or small sailing boats, but these are increasingly being replaced by glass fiber or aluminum boats (dinghy’s) with outboard motors.

[6] Solomon Islands nine provinces (in order of population size); Malaita, Western Province, Guadalcanal, (Honiara), Makira & Ulawa, Central, Isabel, Choiseul, Temotu, Rennel & Bellona. Honiara is included in the ranking list, but is categorised as a capital territory. However, it has its own local government / city council and is therefore distinguished from Guadalcanal province.

[7] SBD 15,759 in annual cash expenditure/income per household and SBD 2,850 per capita is the average in Temotu, which is far less than the national average of SBD 30,069 per HH and SBD 4,887 per capita. At the other end of the spectrum Honiara households has an annual expenditure of more than SBD 75,000

3.1.1. The Reef Islands: location and population

The Reef Islands is a group of 14 small and low-lying islands situated almost 700 km from Honiara and about 60 kilometers north-northeast[8] of Lata and Ndeni Island. The loose connection of 16 small islands covers almost 2500 sq km of ocean, out of which only 1-2 % or about 29 sq km is dry land. By appearance, the main part of the island group resembles a typical atoll formation, where most of the islands encircle a large lagoon. The islands are founded on a coralline base, which forms the rim of an old subsided volcano. Compared to other atolls (e.g. Ontong Java and Sikaiana), the difference is that the eastern part of the island group has been slightly elevated, such that the highest point is about 30 m above the sea. As opposed to this, the western part appears to have been slightly submerged, as there are no permanent islands. However, five small atoll islets are detached from the main part of the island group (see fig. 5), which may be a result of the gradual subsidence and/or subsequent volcanic activity[9].

Politically, the Reef Islands are included in the Pele constituency under Temotu provincial government, which have their headquarters in Lata. However, in terms of local politics, language and culture, the Reef Islands group is usually divided into two subgroups; main Reef and outer Reef Islands. Usually "Main Reef" includes the 9 eastern-most islands inhabited by speakers of the Äiwoo language, but often referred to as Melanesians (i.e. Lomlom, Ngawa, Ngatendo (Pigeon Island), Ngadeli, Ngalo, Nimbanga Temoa, Nimbanga Nende and Fenualoa), while "Outer Reef" includes 5 smaller islands/islets inhabited by Polynesian speaking communities (i.e. Nifiloli, Pileni, Matema, Nukapu and Nupani). Overall the Reef Islands has a high population density with about 5,500 people occupying the 29 sq km of land (~190 per sq km), although this varies as a result of temporary migration. A majority around 5,000 lives in the Melanesian islands, while only 5-600 lives in the Polynesian Outliers, but the population density is higher on some of the outliers (e.g. Pileni > 600 per sq km).

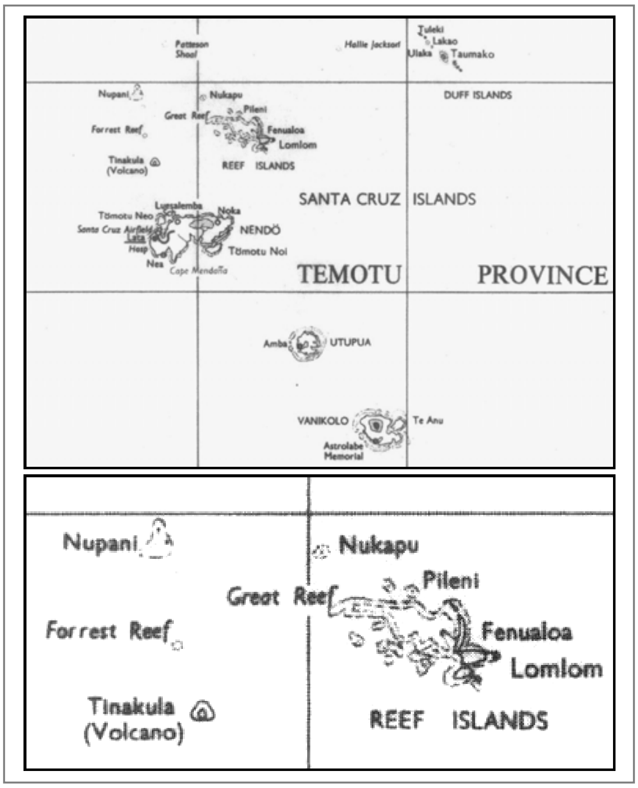


Fig 5: The first map shows Temotu province (excl. Tikopia and Anuta), while the second map zooms in on the Reef Islands. See appendix B for a detailed map of the Reef Islands

The livelihood strategies of the inhabitants in Main Reef are quite similar to those applied by rural communities elsewhere in Solomon Islands. Crops like yams, kumara , breadfruit and cassava are grown in small gardens alongside coconuts and bananas, and represent the main part of the diet. This is complemented by shells, crayfish and fish collected from the rich coral waters surrounding the islands, and at special occasions; meat from turtles, birds (e.g. chickens) and pigs. Surplus food is often sold

[8] The approximate distance by boat between Reef and Lata, the provincial capital of Temotu province and located on Ndeni island. Based on GPS measurements

[9] About 40 km southwest of the islands, the exposed summit of the volcano Tinakula continues to show activity, which is indicated by the smoke rising from its cone. The massive volcano rises 3-4 km from the sea floor and about 850 meter from the sea surface.

or exchanged at the local market or shipped off to family and relatives living outside the Reef Islands, e.g. in Honiara.

For many years the production of copra from dried coconut meat was the most common source of income, but raising pigs has gradually become more important as an export commodity. Also, dried breadfruit and nuts are sometimes exported to markets in Lata and Honiara, but more often to relatives in exchange of food and commodities. Finally, labor migration represents an important livelihood strategy, when a household member travels temporarily (or permanently) to Honiara in order to find employment and steady income. Remittances, in form of cash, food or other commodities, are extremely valuable to families staying behind and probably the most important coping strategy in times of crisis. This strategy is far from unique to the Reef Islands, since it has been common allover Solomon Islands and elsewhere in the Pacific for many decades. In Temotu, labor migration and remittance strategies replaced the traditional trading system between the islands of the region. Along with the increasing importance of cash, the unique red-feather money also lost its meaning (E.g. Davenport, 1962), although there have been recent attempts to revive these customs.

3.1.3. Agriculture and environment

Compared to the rich volcanic soils in the larger islands, the sandy soils in Reef Islands represent a clear environmental constraint, especially in terms of agricultural potentials. All the islands derive from coral remnants and hence, the soils are highly alkaline and nutrient deficient. Admittedly, the interior of the largest islands of Main Reef soils are, compared to the small low-lying islands, more mature and have a relatively high content of soil organic matter in the upper layers, whereas the small outlier islands have sandy soils with thin layers of organic material.

In most parts of the islands, land has come under quite intensive use and the fallow periods have gradually been reduced, which is partly a result of higher population densities. Hence, the natural regeneration of 'bush' areas has come under increasing pressure from a growing population and changed demands of food production. According to local informants, the soils have become less fertile and more susceptible to pests.

Moreover, the pressure on resources has meant that the numbers of (large) trees have been drastically reduced; followed by a rise in timber prices and reduction in fruit yields. From an ecological viewpoint, the reduction of trees may have had significant effect of the biological diversity in the islands, which act to reduce the overall resilience of the ecosystem. The pressure on natural resources may become a serious problem, which could influence food security in the Reef Islands group in general, but particularly in the islands with highest population density. Apart from an apparent need to address population growth though family planning and education, there is also a growing need to improve agricultural management strategies in order to allow productive intensified land use (e.g. use of compost, manure, tilling etc.).

<u>Common food crops</u>:
Kumara
Wild yams
Taro
Pana
Cassava
Taro
Banana
Breadfruit
Coconut
Nuts (cutnut, auiki, alite etc.)
Cabbage
Beans
Pepper
Tomato
Onions (charlot and garlic)
Egg plant
Cucumber
(Chili)

Fig. 6: A list of the most common food crops in the Reef Islands

Coconut, banana, cassava, yams and kumara (sweet potato) are considered the most important food crops grown in the Reef Islands. Fruit trees are also extremely vital for the provision of vitamins and food at certain times a year, especially the breadfruit and various kinds of nuts, together with other fruits. Apart from these, there are many vegetables such as cabbage, green pepper, tomatoes and beans providing people with essential vitamins and dietary needs. While the coconut and several types of banana grow well in all of the islands, kumara and yams is mainly grown in the larger islands. The same goes for cassava, and some vegetables, which do not grow well on in many Outer Reef islands. As an alternative, people in the outer islands grow different types of the traditional taro root crop in artificial swamps and sandy soils. Although the taste of taro is not fancied by many, it is essential in atoll's agriculture and particularly important in times of disaster, when fermentation methods are applied to preserve cooked taro up to several months. In Main Reef, the breadfruit has been preserved in the same way, but also in dried form as a biscuit-like treat. If kept properly, the dried breadfruit ("Nambo") may last for more than a year. This and other types of dried fruit are quite popular as a lunch snack for school kids and others, but traditionally (and still) this technique was used to provide vital supplies for long journeys at sea and at home in times of crisis.

Although many food crops are grown locally, rice has become a favorite supplement to locally grown food. Recently, local production of rice has been promoted in Nende / Santa Cruz and elsewhere in Solomon Islands by Asian business partners and development organizations, but it is unlikely that this will become an option in the Reef Islands. Compared to traditional crops, rice is easy to store for long periods of time and therefore provide an alternative to fermentation methods, which involve time consuming work and takes skills to practice. Moreover, the rice imported from Asia is enriched with vitamins and therefore satisfy the basic dietary needs at low costs. Based on the current trends, rice and tinned fish will gradually replace other types of disaster food in times of crisis. It is also a preferred 'tool' of the government, when they are requested to provide assistance in response to disaster-like situations. One of the results of these changing dietary demands, is an increased dependency of outside assistance.

It could be argued that while communities are utilizing the improved access to imported commodities, they have also exposed themselves to new challenges and come to rely more on food aid (i.e. remittances and relief supply). Hence, when local food supply is running low, communities tend to call for relief supply from the government, instead of revising traditional coping strategies. Hence, the increased confidence in aid and remittances, together with the negligence of alternative measures, has had a clear effect on community resilience in relation to food shortages. With regards to future climate changes and other stressors, the local capacity to adapt has clearly changed, since it is now highly determined by a functioning infrastructure and the performance of the government and aid donors.

Also, the concept of 'disaster' seems to have changed in recent years, including the factors determining the release of disaster aid from donors and the government. This change has partly been associated with the nature of recent events and hazards; in particular the tsunami incident in 2007 which caused the death of 52 people in western Solomon Islands. Also, the increased international attention to climate change issues has led to a renewed focus on disaster risk management. However, in order to make a distinction between natural hazards (e.g. tsunamis, earthquakes, extreme weather events) and stressors arising from structural barriers or mismanagement or resources, there is a need for improved procedures and policies which support context-specific solutions. As hinted above, there has been a growing emphasis on relief and recovery processes that prioritize a return to normalcy, instead of focusing at capacity building and disaster risk reduction.

As an example, in late 2009 the Reef Islands received a shipment of rice representing a belated government reaction to food shortages in the islands. Although the food situation at that time was critical, this could have been prevented through improved agricultural management strategies. The increased risk of food shortages was recognized in a report by the National Disaster Management Office (NDMO) and others already in 2005 (SIRC *et al.* 2005), but it appears that nothing further was done until 2008/09, when the NGO World Vision initiated an externally funded project aiming at improving the local food security and self-reliance in selected Reef Islands communities. At the time of this author's last visit in March 2010, there were some signs of improvement resulting directly from this project. However, as will also be discussed below, there is still room for further development work in the Reef Islands when it comes to addressing the underlying drivers of food shortages and other challenges. For this to happen, a better collaboration and exchange of knowledge between development organizations and government institutions is crucial.

3.1.2. Cash economy

As previously argued, stable and sustainable income opportunities have become increasingly important for Reef Islands. In recent years the income from export of copra and marine resources has been slowly declining due to changes in market prices, rising transaction costs, and national conservation efforts. Various national and overseas development initiatives have aimed at strengthening economic activities in Lata and other parts of Temotu Province, but they all seem to have failed – coinciding with the termination of external financial and technical support. The production and trade of copra, including the milling and processing of coconut oil, has increasingly been restricted to areas which have favorable conditions for foreign investors and well-functioning infrastructure. Hence, the high transaction costs associated with production in Reef Islands have made this location less attractive, and as a result local buyers are gradually pulling out of the business and the demand for copra has been reduced significantly. In terms of marine resources, the government's ban on the export of beche de mer (sea slugs) in 2005, which was imposed as a response to perceived overexploitation, has also had a significant effect on income opportunities in Reefs, particularly in Outer Reef. The export ban has been lifted temporarily (1-3 months) a few times as a reaction to pleas from the local government in times of hardship, but this only provided momentary relief for Reef Islanders and not stable solutions. Moreover, according to local informants the high transaction costs result in low prices and imply that most of the revenues are collected by middle men and buyers in Honiara.

Currently the most important source of income for many households is the raising and export of pigs to Lata or Honiara. Again, there is large transport costs associated with this trade, and in the end profits are relatively small compared to the work invested in feeding and looking after the pigs. Nonetheless, apart from subsistence production, the pigs represent a vital livelihood strategy of many households. A household survey revealed that the majority of families are involved, with an average of 4-5 pigs/piglets per household. However, while most households intend to export their pigs or piglets to Honiara or Lata, and thereby earn a good price; quite often people sell at much lower prices to local buyers or donate the pigs for local ceremonial feasts. As an example, the ordination of a priest and visit by the arch bishop was celebrated with a big communal feast in Tanga Village, Fenualoa Island – at this occasion around 60 pigs were donated for the feast by a number of individual stakeholders and communities, equivalent to a market value of about SBD 50-100,000 if sold in Lata or Honiara.

In addition to the trade of cash crops, marine resources and pigs, a small number of households manage to obtain a steady income from government paid jobs, either through employment as teachers, nurses or government officials. The salaries associated with these jobs are quite low in the Reef Islands compared to Honiara, which is mainly explained by central regulations defining wages according to the perceived local living costs. Admittedly, it could be argued that unequal wages is yet another barrier for economic development in remote rural areas. Even so, compared to local standards, the Reef Islanders who have jobs are typically quite well off. Moreover, a steady income also provides these families with vital capital, which may be invested in small-scale business. Thus, local teachers and government employees often have side jobs as shop owners and 'business men' (e.g. buyers of beche de mer, pigs, shells etc.) or support/invest in the private enterprises of relatives. Clearly, the success of local shop owners and business men depend on the regularity of shipments to and from Honiara (supply/export of commodities), as well as a steady local demand for their business. Starting business in the Reef Islands is associated with large economic risks, implying that those with side-jobs are less sensitive to fluctuations of supply and demand factors. As an indicator of these fluctuations, the shops in Reef Islands do not have regular opening hours and frequently run low on stocks (e.g. rice, noodles, tobacco, flour) due to the lack of timely shipments.

Apart from rice, noodles, sugar and biscuits, the preferred expenditures are imported tobacco, betel nut and canned beer. Apparently, the Reef Islanders are quite renowned for their consumption of canned beers, although not many can afford this luxury. At prices of SBD $15 per beer can and $2 for either one betel nut or an inch of tobacco, there are barely any locals that have an income level allowing for a regular use, at least not without draining the household savings. While this is sometimes the case, the purchase of alcohol often coincides with the infrequent arrival of a shipments and/or the bimonthly payment of salaries to government employees.

As elsewhere in Solomon Islands, customary feasts and communal ceremonies quite often involve significant financial costs to households, since these events are associated with high expenditures on food, gifts, tobacco and betel nuts etc. In the occasion of marriages, priest ordinations (see above), child births, maturation rituals and other ceremonies; the role of food banquets and cash gifts is extremely important in order to follow customary rules and to please the invited guests. Based on a household survey, Reef Islanders rank these expenditures as an important driver for the increasing demand for cash income[10]. Sometimes, the heavy obligations to 'kastom'[11] present a barrier for economic growth, since they drain household savings and create disincentives for private investment (entrepreneurship). On the other hand, the many ceremonial events and the kastom-system stipulate the maintenance of social networks and collaboration within communities, which function as an insurance and social security mechanism in times of hardship[12]. These and other important cultural mechanisms are not easily replaced, implying that future attempts to stipulate socio-economic development in the Reef Islands needs to recognize and, if feasible, promote the positive aspects of traditional life.

3.2 Current and future climate change exposure

One of the main purposes of the study in Reef Islands was to assess local people's exposure to climate variability and change. The methodological approach involved a survey including more than 100 households, as well as numerous key-informant and focus group interviews in different villages and islands.

Overall, the findings suggest that people in the Reef Islands themselves are quite aware of the risks associated with climate variability and change, and how they have an effect on their daily lives. Moreover, many respondents expressed their concern and alertness in reaction to the observed trends and incoming news indicating an exacerbation of these risks in the future. Although part of this awareness came out of peoples own experience with the local weather conditions and known impacts of extreme events, the alertness about future changes was primarily based on inputs from outside information sources or public awareness campaigns (i.e. NGO's, government, the media). There is a common agreement about the frequency and intensity of extreme weather events, as well as their impacts and peoples response. Also, there seems to be a widespread agreement in relation to observed trends of weather and climate conditions. In contrast, the discussion about future changes was difficult for many, often because they had no idea what to expect or since they had become disillusioned with the gloomy prospects reported by news media and policy makers. However, the introduction of basic scenarios and

[10] As example, bride prices have increased considerably over the last decades. Since it is the groom's family that pays the bride price, young men have to wait longer before their families can afford the bride price and wedding. Again, labor migration and remittances play an important role in the household cash economy, and young men are increasingly encouraged to contribute towards their own bride price, which often means that they will have to search for employment elsewhere.

[11] Customary rules, traditions and codes of conduct are often referred to as 'kastom'

[12] For many generations the kastom rules in the Reef Islands have prescribed for people to share wealth of any kind (food, money, skills etc.) among their kin folks

projections adopted from the IPCC reports (Rasmussen *et al*, 2011; Mimura *et al*, 2007) resulted in quite fruitful group discussions about potential exposure and sensitivity, as well as adaptation needs and options.

3.2.1. Current exposure and sensitivity

Based on household interviews it became evident that many coastal areas, particularly of the lowest lying islands (Nukapu, Pileni, Matema, Nifiloli, Ngadeli) are exposed to storm surges and tidal waves, which have lead to flooding of settlement areas and agricultural fields. This is often associated with weather events, such as cyclones and tropical storms. Apart from the immediate destructive effects, these events are followed by long periods of ecological and psychological rehabilitation, when people are at higher risks of food shortages or malnutritious diet; diseases; lack of drinking water etc. The larger islands of Main Reef are less susceptible to these damages, since many garden areas are in safe distance to the sea confined from the wind by standing trees. Also, the fringing reefs and shallow lagoon provide important protection from incoming waves. As opposed to this, the small islands of Pileni and Matema are almost entirely exposed to the open sea from all sides, and due to their low topography, all parts of the islands are at risk of flooding and salt water intrusion. A result of cyclone Nina in 1993 was a storm surge that almost flooded the entire island of Matema, which had significant impact on the garden areas, but also on the island morphology. The picture below illustrates a trench which was dug out by waves washing across the island.

Admittedly, the frequency of cyclones affecting Reef Islands is rather small (20-50 years), but the intensity and destructive forces associated with the most recent events have been quite strong after local standards. Cyclone Nina caused significant impacts on all of the Reef Islands; particularly in the Outer Reef islands (Nifiloli, Matema, Nukapu, Nupani and Pileni) and southwestern parts of Main Reef (e.g. Ngadeli). In addition to the damages caused to trees and buildings, the impacts on the agricultural production were severe as many crops were completely devastated. Also, the livestock of many households were swept away by the incoming waves and killed. Fortunately, none of the islanders were killed, which was probably due to the fact that the storm occurred at daytime.

Picture showing a large area next to the community Saplau (meeting area/house) which have been excavated by high magnitude waves

Hence, the human costs associated with these events are considerable, and it takes several years for people to regain their losses. However, the island ecosystems are quite capable of bouncing back in response to natural disturbances, and as previously mentioned, the nature of high magnitude events can be essential for the long-term stability of atoll ecosystems.

Compared to extreme weather events, gradual changes in climate conditions and the associated effects are quite subtle and difficult to detect at a local scale, especially since there has been no systematic measurement and registering of changes in climate and weather patterns over the years. Therefore, the information of climate variability and changes has to be reconstructed from people's memories of the past, which is not unproblematic from a scientific point of view. As previously explained, climate proxies are often measured in quantitative terms (using meteorological equipment), whereas people's recollection of the past weather is expressed in qualitative terms. As example, the common answer to the question "do you see any changes in precipitation levels over the last decades?" is "yes" or "no" or "don't know". Subsequently, when people reflect on the direction of changes, it is often expressed in qualitative terms such as “more”, “less”, “more often” or “more intense” etc. Although such statements are by some means inexact, they provide valuable information about the local reality as perceived by people (who rely much on the weather). They are more likely to act upon this perception of reality, than on scientific outputs represented by graphs and numbers. Moreover, the qualitative data of locally perceived changes in climate conditions can be compared with regional climate observations, including the assessments of the IPCC.

Actually, the findings of the IPCC are often translated into qualitative statements, such as the “increase” or “decrease” of precipitation, or “less frequent” and “more intense” storms, which makes them more relevant to planners and policymakers. In most cases, the observations by the IPCC describe the climate conditions on a regional to a global scale, implying that local deviations occur but have been smoothed out for the sake of analysis. As a result, the IPCC summary of climate change in the Pacific reflects an average condition or trend, and does not apply to all sub-regions. Local observations are therefore extremely valuable for the downscaling of regional trends.

Impacts from climate events	Last 5 years	Last 10 years	Last 20 years
Storms	39 %	55 %	80 %
Droughts	55 %	57 %	70 %
Floods	32 %	37 %	47 %

Fig 7: This table shows the percentage of households strongly affected by extreme events within the last 5-20 years. The effects were mainly water shortage, damage of buildings and crops. The table is based on a sample from 104 households (≈ 500 people)

Based on interviews with key informants in Reef Islands, there is no indication of an increase in the frequency and intensity of extreme events. This local observation is consistent with the regional analysis of the IPCC (Trenberth *et al.* 2007). Instead, many local respondents explained that the stormy ‘cyclone’ season (Kumberra/kuburu) has become less persistent and harder to predict, which is taken as a sign that the climate is changing. However, in this case the impacts of changes do not seem negative, since the unrelenting strong winds in Dec-Jan used to be a nuisance to people. On the other hand, the predictability of the weather patterns and onset of seasons is important for local people in relation to the planning of livelihood activities and therefore, the perceived changes act as a cause for confusion and alertness. To a large extent, the Reef Islanders capacity to cope with climate stressors relies on their ability to anticipate the change of seasons, and when elders and chiefs start to express disbelief in this ability, this tend to increase the overall vulnerability of the community. Hence, the observed changes in wind patterns are perceived by local stakeholders as a negative climate change effect, although the reduced intensity and/or persistency of storms could be interpreted as positive.

When it comes to precipitation patterns, there was disagreement among interviewees about the reconstruction of historical trends. Hence, some were stating that precipitation levels (frequency and intensity of rainfall) had increased significantly, while others had observed the opposite. Based on this, there is no clear indication whether precipitation in Reef Islands resembles the trends illustrated by rainfall data from Lata meteorological station (see above). In relation to national rainfall assessments, which report a significant decrease of precipitation at most stations over the last decades; the interview data from Reef Islands cannot act to confirm or disprove these observations.

Correspondingly, there is no clear indication of higher frequency or intensity of dry periods or droughts in the Reef Islands. Admittedly, such changes can be difficult to reveal through qualitative interviews, since there are several ways to define the concept of drought. A *meteorological* drought is defined according to average rainfall, implying that a prolonged period (e.g. a month) with less than average rainfall may be conceived as a drought. *Agricultural* droughts are droughts that affect crop production or the ecology. This condition can also arise independently from any change in precipitation levels when soil conditions or human (mis)management cause a shortfall in water available to the crops. *Hydrological* drought is triggered when the water reserves available in sources such as aquifers and rainwater tanks begin to fall short and are not replenished. Like an agricultural drought, this can be brought about due to other drivers than just rainfall deficiency.

In terms of drinking water, the increased use of rainwater tanks since 1970's has strongly improved the access to and management of drinking water in the islands. Most of these tanks have been provided by development agencies (e.g. AusAid and World Vision), which have been highly appreciated by communities. The only problem is that many communities do not have the capacity to maintain these tanks or replace the old ones. Also, considering the number of tanks in different villages, the allocation of tanks between and within communities does not seem to have been entirely reasonable and fair. Thus, many households still rely on water from open wells, which is less suitable for drinking and can be associated with health problems. For the sake of future 'well-meaning' development initiatives, there is a need to ensure fair and equal approaches in the preceding assessment of problems and needs. Furthermore, the decision-making processes leading to the allocation and placement of benefits (water tanks, building, boats etc.) have to be transparent and participatory. Such steps reduce the risks of politicizing projects and create unnecessary disputes among the end users.

Pictures from Matema (left) and Ngadeli (right), where many households still rely on water from underground aquifers.

With regard to agricultural droughts, most of the crops grown in Reef Islands are fairly resilient to water stress (e.g. coconut, banana), but people express that losses are experienced every year during the dry season. Many vegetables are particularly sensitive to water deficiency, which means that irrigation and mulching is often necessary. However, some respondents expressed concern with the severity of occasional or interannual droughts (associated with the El Niño), but they had not experienced this within the last 10 years or so.

One of the main environmental concerns among Reef Islanders is coastal erosion and sea level rise. The latter has supposedly been observed to cause significant impacts in many settlements over the last decades. As example, Tuwo village in Fenualoa Island has gradually lost their traditional burial ground to the sea, which is seen by many as a sign of accelerated sea level rise. Consequently, people have tried to prevent this erosion by building stone dikes in front of their houses. In the small Outer islands, the effects of coastal erosion are a large concern, since many fear that the islands are at risk of being washed away, especially due to the observed effects of cyclones (see above). Clearly, it has to be recognized that coastal erosion can be observed at almost a daily basis, while gradual sea level rise is practically impossible to detect without the use of exact measuring instruments. However, there is an evident link between the erosion and sea level changes which has been subject to thorough studies in recent years. Coastal erosion has always taken place, since islands are constantly exposed to the dynamic forces of the sea. In some periods, the direction of winds and currents lead to an accumulation of sediments, while at other times the opposite is the case. Hence, islands should not be seen as stable or static landforms, but rather as dynamic units under constant influence of the surrounding environment, as well as subject to changing human management. It is tempting to establish a direct causal link between ongoing erosion and sea level rise, but the connection is often not that simple. To study the effects of sea level rise, there is a need to consider the natural ology and Conservation ADDIN REFMGR.CITE <Refman><Cite><Author>MECM</Author><Year>2008</Year><RecNum>3700</RecNum><IDText>Solomon

changes in tides and sea level, which may then be compared to erosion rates at a nearby coastal area. This is the only gauge station in Solomon Islands and therefore this method is not an option in the Reef Islands. Instead, other approaches may be used to observe the long term effects of erosion. As an example, it can be useful to compare recent satellite images with older aerial photographs (ortho photos) taken by the the English military (or others) during overflights at various occasions since World War II. Actually, the comparison of ortho photos from the early 1970's with recent satellite images show no indication of net erosion in the Reef Islands (e.g. Annex 3). Surely, erosion is taking place, but the net effect is very small. Sediments are removed from certain points along the coastline, but apparently accumulated elsewhere, so that the total land size remains approximately the same. Hence, despite the generally accepted view among national policy makers (e.g. MECM, 2008), there is no clear sign of accelerated erosion as caused by sea level rise – at least not based on this approach.

Admittedly, it is possible that the Reef Islands have been subject to geological or tectonic movements (isostasy) which may have counterbalanced the changes in sea level (eustasy) and reduced the local effects.

Pictures from Luaniua, Main Reef (top) and Matema, Outer Reef (bottom), illustrating the local effects of erosion. In Luaniua, coral stones are used for protection against erosion

3.2.2. Future changes and their potential impacts

According to the IPCC, atoll and low-lying reef islands are among the most vulnerable to the impacts of climate change. This is not only due to their biogeophysical characteristics, but also because they face great challenges in terms of socioeconomic development.

In the Reef Islands, some of the islands are extremely low-lying and therefore seem particularly sensitive to sea level rise. Based on the warming trends, recent projections suggest that sea level rise could arrive at somewhat 20-50 centimeters above current level by the mid 21st century, while longer term changes are more wide-ranging. As previously noted, Rahmstorf (2007) and others propose a likely 0.5 to 0.9 meter increase by the end of the century. Although these changes may vary across the globe and even within regions, it is likely to have significant impacts on coastal areas and settlements, where people live close to the sea and of the resources the sea provides. In the Reef Islands many areas that are currently occupied by villages and settlements will gradually become more exposed to flooding and coastal erosion, implying that some kind of adaptation will be needed. With regards to the small atoll and reef islets, like the Polynesian outliers (Outer Reef), these may not be capable of withstanding the long term effects of sea level rise and the associated erosion, salt water intrusion and partial inundation (Dickinson, 2009).

Climate changes also include alteration of precipitation patterns. The projections of changes in rainfall involve a high degree of uncertainty, since some climate models project a general increase in rainfall, whereas others project a decrease in the Pacific region. Clearly, higher temperatures in the lower parts of the atmosphere are likely to be followed by increased evaporation of water from the sea surface, which again is likely to cause more cloud formation. However, the climate of the Southwest Pacific is influenced by many factors, including the complex trade wind patterns, and therefore rainfall patterns are extremely difficult to predict. In the case of an increase, the Reef Islands, compared to many other islands in the Solomons, are not particularly vulnerable to floods as caused by heavy rainfall events. In contrast, a decrease in rainfall is likely to be more critical, since the atoll soils are highly permeable and does not support underground aquifers well, which means than they quickly dry out if there is a prolonged deficiency of rain. The small islets are sensible to saltwater intrusion, which may be exacerbated by a large decrease in rainfall. Moreover, the gradual increase of atmospheric temperatures is likely to be followed by an increase of evapotranspiration from the vegetation and land surface, implying that the ecosystem becomes more sensitive to changes in precipitation.

There are no indications of an increase in the overall frequency of cyclones, but the intensity might increase due to higher atmospheric instability. Hence, the Reef Islands are not likely to experience cyclones more frequently than before, but the magnitude of damages from storms and cyclone winds will possibly increase due to higher wind speeds. Cyclone Zoe in 2004 was the strongest category 5 cyclone ever recorded in the South Pacific, which particularly caused damages in Tikopia. But Cyclone Zoe did not cause any casualties in Tikopia; neither did cyclone Nina when it hit Reef Islands in 1993. Hence, the people of Temotu and the Reef Islands have proved quite capable of withstanding the effects of cyclones, although the economic costs may have been great. Assuming a development of living standards in Reef Islands, including better income opportunities, the economic losses associated with extreme weather events are likely to increase unless proactive measures are taken to avoid this.

Climate change is leading to an increased uptake of carbon dioxide (CO_2) in the upper layers of the ocean. Together with the gradual increase of temperatures, this is likely to cause unfavorable living conditions for coral reefs and the ecosystem they support. Corals are sensitive to the changes in temperature, which has been observed in the occasion of coral bleaching. Moreover, the uptake of carbon dioxide affects the level of acidity in the ocean, which leads to a situation where reef building corals will have less ‘building blocks’ available. According to the IPCC and others (Denman *et al.* 2007; Hoegh-Guldberg *et al.* 2007) this is a likely scenario for the future. As a result, the important functions (eco-services) provided by the coral reefs in Reef Islands may be affected, including the natural protection of islands from storm surges and tsunamis. As example, coral reefs will become more sensitive to high magnitude events and be less capable of recovering subsequent to these and other disturbances. The more immediate effects could be a reduced abundance of marine species, including the great variety of fish living directly of the coral reefs. Understandably, the coral reefs are an important element in people’s livelihoods, since it represents a source of both food and income. It is difficult to imagine how Reef Islanders would survive and thrive in the absence of healthy coral reefs. Therefore, in addition to the projected effects of sea level rise, the potential degradation of coral reefs is very serious for low-lying reef and atoll islands. However, there are no current signs of degradation of coral reefs in the Pacific – at least not due to climate change. Instead, there is widespread concern about the human (mis)management of coastal waters and coral reefs. As human populations increase, so will the pressures on coral reefs, and when

	Climatic stressors			**Non-climatic stressors**		
	Cyclones / storms	Drought	Sea level rise	Environmental degradation	Health	Education
Fenualoa	**	*	**	**	*	*
Lom lom	*	*	*	*	*	*
Ngadeli	***	**	**	**	*	*
Nifiloli	**	*	**	**	**	*
Matema	***	**	***	***	**	***
Nukapu	***	**	***	**	***	***

Fig 8: This table shows the relative differences between some of the islands within the Reef Islands group with regards to perceived sensitivity to climatic and non-climatic stressors, which is ranked as one dot (weak), two dots (moderate), and three dots (strong).

combined with climate change the likely outcome is increased damage to many coral reefs of the region (Lovell *et al.* 2004).

In summary, climate changes are likely to affect the Reef Islands in various ways. However, according to the IPCC there is a high degree of uncertainty associated with the character of climate changes in the South Pacific and their local impacts. Nevertheless, despite these uncertainties there is a growing need to prepare for possible futures, particularly the types of changes that are alarming to the well-being and safety of local people. Based on the low-lying characteristics of the Outer Reef Islands, sea level rise is of particular concern to communities living in these places. In the long term, the risks of increased erosion, salt water intrusion and partial inundation increase, and this will affect the agricultural potential and ground water quality. For the larger and more elevated islands of Main Reef, sea level rise is mainly a concern for near coastal settlements, which face the same types of risks as described above. However, the ability to respond to these changes differs, given that the interior of the larger islands are less exposed and sensitive to the impacts of sea level rise.

3.3 Adaptation assessment: opportunities and constraints

As previously noted the term *adaptation assessment* typically refers to the practice of identifying options to adapt to climate change and evaluating them in terms of criteria such as availability, benefits, costs, effectiveness, efficiency and feasibility.

Adaptation to climate change may be defined as "adjustments to reduce vulnerability or enhance resilience in response to observed or expected changes in climate and associated extreme weather events" (Adger *et al.* 2007, p. 720). It involves adjustments in social and environmental processes, perceptions of climate risk, practices and functions to lessen potential harm or to realise new opportunities. In practice, adaptation tends to be an on-going process, rather than isolated measures. Various types of adaptation can be distinguished, including anticipatory and reactive adaptation, and private and public adaptation (*ibid*):

- Anticipatory adaptation takes place before impacts of climate change are observed. Hence, this adaptation is proactive, rather than reactive.
- Reactive adaptation is often termed as *coping measures*, which may be applied in reaction to rapid onset events such as cyclones. It involves activities such as re-building, re-pairing, re-lief supply etc.
- Private or autonomous adaptation does not only constitute a conscious response to climatic stimuli, but is also triggered by ecological changes in natural systems and by market or welfare changes in human systems. Hence, this adaptation range from spontaneous actions to planned livelihood strategies.
- Public adaptation is often the result of a deliberate policy decisions, based on an awareness that conditions have changed or are about to change and that action is required to return to, maintain, or achieve a desired state. This type of adaptation can be both reactive and proactive

Although climate change, as projected by the IPCC, will be unprecedented in Reef Islands' history, adaptation to climate variability and extreme weather events is not new to Reef Islanders. Since the earliest communities settled on the islands, they have had to cope with the harsh environmental conditions characterizing low-lying small islands surrounded by vast stretches of open sea. The irregular occurrences of droughts, storms, and floods have tested the ability of communities to recover from hazards and adjust their behavior to reduce the impacts of coming events. Moreover, the gradually increased pressure on resources due to population growth together with the changing expectations of living standards meant that people in the Reef Islands had to develop a range of strategies to cope with the challenges presented by these and other circumstances.

Hence, although it is commonly accepted that small island communities are particularly vulnerable, their accumulated experience and knowledge of life in the islands also reflect some degree of resilience or adaptability. These positive qualities may be strengthened and utilized in order for Reef Islanders to become better equipped to deal with the effects of future climate change, which might become a serious challenge for Reef Islanders. Proactive adaptation to the projected adverse effects of climate change is vital in order to increase the overall resilience of communities. To identify and develop sufficient adaptation options and strategies, people in the Reef Islands would benefit from external assistance for capacity building, technology transfer, awareness campaigns and financial aid.

Successful adaptation not only depends on governments but also on the active and sustained engagement of stakeholders, including national, regional, multilateral and international organizations, the public and private sectors, civil society and other relevant stakeholders. Next to building climate-resilience, economic diversification is another good way of creating buffers against climate shocks and for safeguarding development gains made to date

The political situation and the economy in Solomon Islands may be perceived as unstable, which influences the overall institutional capacity in terms of dealing with climate change related challenges. The Ministry of Environment is currently hosting the focal point (climate change division) coordinating national adaptation efforts. Despite the best intentions of its officers, the climate change division is constrained by limited financial and human resources, as well as shifting priorities of the government.

The National Adaptation Programs of Action (NAPA), which is described in a report published in late 2008 by the Ministry of Environment, Meteorology and Conservation (MECM, 2008), represents the governments attempt to identify the national climate change adaptation needs. Although the report identifies a range of potential measures, which could reduce the impacts of climate changes within different sectors or in specific locations (e.g. agriculture, fisheries, human settlements), the process leading to the prioritized list of adaptation projects was hampered by the unstable political situation at that time and the lack of institutional capacity for proper evaluation and implementation of the strategies. Hence, there is a need to evaluate the projects and priorities identified in the NAPA and to take a further step (re)formulating clear policies for climate change adaptation. Moreover, where the NAPA mostly focuses on the needs within or across policy sectors at a national level, more attention and resources have to be directed towards similar work on a provincial and community level. Such work could reveal the diversity within the country and provide a more context-specific view on vulnerabilities and adaptation needs. It would also ensure a more decentralized process towards planning and decision-making, and potentially enhance the transparency of policies and create local ownership.

Admittedly, low-lying reef and atoll islands were given special attention in the SI NAPA. Their vulnerability to climate changes effects such as storm surges, erosion and sea level rise together with their general lack of adaptive capacity to respond to these changes was emphasized. As a result, the option of relocation and evacuation of communities was seen as “one of few practical options (if not the only one) for adaptation” and therefore short listed as a high priority in the NAPA (MECM, 2008). The urge for relocation of these communities was restated by members of parliament at a meeting in 2009, but has not been implemented yet.

Given that Reef Islands were included among the low-lying reef and atoll islands in Solomon Islands, which are under discussion in relation to the government’s proposal of relocation, this adaptation option will also be considered in the following. However, it is evident that relocation is seen by many as an option of last resort, and therefore a range of alternatives will be considered as well.

3.3.1 Adaptation options

As hinted above, the various options for adaptation differ in terms of costs, efficiency and feasibility. Adaptation is often mistakenly interpreted as extraordinary measures which will drastically change the daily lives of those that adapt. While this may be the case for certain types of adaptation, most often adaptive measures and projects involve rather small adjustments and modest changes of existing practices. Moreover, adaptation projects are often similar to or overlap with initiatives termed as 'rural development' or 'disaster risk management'. Hence, the potentials of an integration of these policy sectors, which have traditionally been separated, seems obvious; as this would provide opportunities for mutual exchange of knowledge, more cost-efficient implementation, and ensure that adaptation and disaster risk management supplement the national objectives of sustainable development (e.g. millennium development goals). In Solomon Islands, the portfolio of adaptation projects are still very limited and alternative adaptation options therefore relatively unexplored.

<u>Awareness campaigns</u>

As previously described, there is a need of strengthening the local capacity to deal with climate variability and change, as well as hazards and extreme weather events. Based on interviews in Reef Islands, many have heard about climate change, but often from the media or relatives living in Honiara. Although these sources of information are vital for the exchange of knowledge, they tend to focus on sensational news, which is not always appropriate as a basis of understanding certain issues. Other important sources of information include politicians and government officials, as well as NGOs and teachers (at local schools).

As a result, the local perceptions of climate change are reflecting all kinds of inputs. Among the islanders themselves, there were different perceptions of the nature of climate change and its effects, but many respondents referred to information provided by visiting NGOs or politicians. Apparently, the received information has lead to more confusion about the potential consequences of climate change, than actual awareness – which was probably the intention. Moreover, some of the information provided, have brought about anxiety or even fear among some communities, in consequence of a skewed focus on worst case scenarios. As an example, a group of men from Matema Island told that a Honiara politician running for reelection visited the island, and made promises that he would attend the issue of climate change if elected for national parliament. According to the men, he explained them that Matema was likely to be washed away within 10 years as a consequence of sea level rise. He also made promises that Matema would be granted land elsewhere and compensation for their losses. In Matema, the chief explained that they believed the politician and became anxious about the future. At the same time, the people of Matema did not want to move away from the island unless it was absolutely necessary. Actually, the chief expressed that some of the inhabitants would stay no matter what.

Awareness campaigns can be a good starting point, which may be combined with participatory assessments

Typology of participation in policy-making

1. *Participants listening only* (e.g. receiving information from a government PR campaign or open database).
2. *Participants listening and giving information* (e.g. through public inquiries, media activities, "hot-lines").
3. *Participants being consulted* (e.g. through working groups and meetings held to discuss policy).
4. *Participation in analysis and agenda-setting* (e.g. through multistakeholder groups, round tables and commissions).
5. *Participation in reaching consensus on the main strategy elements* (e.g. through national round tables, parliamentary/select committees, and conflict mediation).
6. *Participants involved in decision-making on the policy, strategy or its components.*

At each level, participation may be narrow (few actors); or broad (covering all major groups as well as government).

Adopted from Bass *et al* (1995)

involving local stakeholders (village council, chiefs etc.), where the needs and priorities of the various communities are identified, and different types of solutions sketched out. However, referring to previous discussions of place-specific climate change impacts, it is important that the information provided has been adjusted to context-specific circumstances and will be delivered by experienced stakeholders. Moreover, it is imperative to be clear about the uncertainties associated with long term climate change and to avoid unnecessary 'fear mongering' and a skewed focus on worst-case scenarios only. Fear is rarely a good starting point for practical decision-making.

Consultation / participatory adaptation

Following the previous section, the process of consultation and participation is an important element in the adaptation assessment. Likewise, the actual implementation of adaptation projects and measures has to involve local participation and to build capacity among local people, since adaptation is not only about engineering sea walls or installing water tanks. Although this was also recognized in the NAPA report, the consultation process in communities is somewhat schewed towards easy-access communities. As example, atoll communities on Ontong Java, Sikaiana and Reef Islands were not consulted as part of the NAPA process (see MECM, 2008). Hence, the Solomon Islands government needs to focus on; how to support a more decentralized approach to adaptation. In terms of cost-efficiency, decentralized decision-making will not necessarily be more costly for the country than central planning. There are plenty of examples showing that local influence on policy-making leads to better results of national planning. With regards to climate change adaptation, local participation at an early stage is likely to increase people's understanding of the problems and their support for the potential solutions. Local participation can be organized in many ways, which is demonstrated in the table above. See also annex 4 for examples.

Engineering solutions

It could be argued that the most obvious approach to adaptation in small islands is through engineering solutions. As an example, the construction of sea walls, stone dikes and wave breakers has been a favored response to erosion and sea level rise. In response to water shortages, many communities have been provided with rain water tanks. Also, permanent buildings such as health clinics, schools and churches are increasingly constructed to withstand the impacts of extreme weather events and natural hazards.

In many cases, these solutions may be suitable, but also involve high financial costs and technical skills, both in terms of implementation, maintenance and replacement. Hence, the engineering approach is not always the most appropriate. Moreover, in some cases the construction of artificial protection gives a false sense of security. As example, there are various ways for the artificial accretion of land. Concrete sea walls and wave breakers may reduce the impacts of extreme events, but they are rarely suitable for the alleviation of erosion problems or for adaptation to long term effects of sea level rise. As an alternative, it is possible to dredge material from the bottoms of lagoons and using the material to create land. This may be applied as a means of protecting the most low-lying areas, but will require a lot of sand and coral. In some cases, this exercise could be done at low costs, whereas other would require large investments, including the use of pumps.

Based on the assessment in Reef Islands, the construction of sea walls is not appropriate. Instead, some communities have expressed their need for the installation of more rain water tanks. These have to be imported from outside and are rather costly, at least after local standards. Hence, it has to be considered how the problem of maintenance and replacement is solved.

There are other more immediate challenges to be attended to, which may benefit from the transfer of technologies. These include power/electricity (e.g. solar panels), preservation and preparation of food (e.g. ovens, driers etc.), agricultural techniques (e.g. tools, compost systems etc.), communication (e.g. improved access to mobile network, internet, education material etc.)

Ecosystem-based adaptation

The promotion of ecosystem management practices, such as biodiversity conservation, can be quite useful to reduce the impacts of climate change on people. As example, in Reef Islands the natural vegetation has been gradually removed and/or replaced to make way for the expansion of villages and settlement areas, as well as agricultural fields. The removal of vegetation increases the risk of erosion and soil degradation. Hence, the (re)planting of coastal vegetation and mangroves might reduce the exposure to erosion and the effects of sea level rise.

Other types of ecosystem-based adaptation include; conservation of fish breeding locations and key habitats by use of quota systems or 'tabu' rules (no-take areas); more efficient use of mulching, composting and crop rotation to preserve soil moisture and fertility; consistent efforts to fight introduced pests like ants, rats, flying fox, and caterpillars; sustainable exploitation of natural forest areas through strategic reforestation and protection of valuable species etc.

Ecosystem-based adaptations are most often cost-efficient and have many positive side effects, even in the absence of the projected climate change effects. Hence, this type of adaptation matches the criteria of the 'no regret' policy of the government, implying that positive results can be expected under most circumstances. The ecosystem-based approach to adaptation assumes that sound (or sustainable) environmental management enhance the resilience of ecosystems against a wide range of disturbances. Moreover, in order to increase the chances of successful ecosystem-based adaptation, the character and demarcation of the ecosystem in focus should be considered carefully, since various factors could influence or restrict the management, including socially defined boundaries (fishing grounds, land tenure, village boundaries etc.) and economic activities.

Strengthening existing / traditional practices

The communities in the Reef Islands have a wide range of social practices which may be strengthened, systematized or in some cases reintroduced. As example, various food preservation methods were traditionally applied as a proactive and/or reactive measure in times of food shortages or in response to extreme events. In Reef Islands there are several types of 'disaster' food, which people used to rely on at certain times a year. Dried breadfruit or "nambo" is a well-known biscuit-like treat, which have lost some of its importance due to the increased imports of rice. The same goes for other types of preservation / fermentation techniques. Moreover, there are also certain crops which are gradually losing their importance, including slow-maturing root crops like wild yams and taro. Again, the reason is that people replace their use with imported goods, which is quite understandable. At the same time, this also implies that people become more dependent on aid or relief supply from the government, development organizations or from family members living outside the islands.

Additionally, increased capitalism together with the 'erosion' or weakening of local institutions (chiefs, kastom etc.) has had an effect on the traditional social security network, where surplus food and wealth was redistributed among community or tribe members in hard times. Moreover, the loss of authority among the traditional leaders has led to an increase in theft and unlawful behaviour. These changes have been exacerbated by growing population density and increased scarcity of land, implying that young families have less land to live from. In the absence of sustainable techniques, the scarcity of land leads to shorter fallow periods, followed by gradual reduction in soil fertility.

In order to ensure that better information reach the ‘end-users’ and local decision-makers, the officers at national and provincial level will need to develop proper guidelines for participatory consultations, and adopt methods and tools for the assessment of adaptation at a local scale. Some of these tools are available through the South Pacific Regional Environment Program (SPREP), who can also provide guidance and expert assistance. Other important stakeholders could be identified through the University of the South Pacific (USP), who may also be interested in collaboration in terms of the education, training and public awareness on adaptation, especially for young people.

<u>Community relocation</u>

The NAPA (MECM, 2008) identifies community (inter-island) relocation as one of few (if not the only) practical ways of adapting to sea level rise in the low-lying reef and atoll islands (e.g. Outer Reef, Ontong Java, Sikaiana). Relocation and resettlement programmes have their costs and benefits; people are moved away from physical exposure to hazards but may face loss of land and resource entitlements, and therefore loss of livelihoods after resettlement. If this happens, this might force relocated households to depend more on governmental and international aid. In Solomon Islands, this problem is exacerbated by the present land tenure systems and regulations of ownership. Hence, the relocation of whole communities is likely to create a whole range of new vulnerabilities.

Assuming that relocation comprises an extraordinary adaptation measure and an option of last resort, there is a need to identify adaptation strategies that allow people to remain where they currently live, and exhaust these alternatives before people are required to relocate. In so far that communities and the government decide to instigate a course of action that follows the NAPA proposal, there are important issues relating to the question of how, when, and to where, which need clarification.

In planning for relocation of Reef and atoll island communities, there are lessons to be learned from historical examples (e.g. Kiribati in Titiana/Gizo, Tikopians in Russell Island and Makira etc.). Although comparative histories are often embedded in different socio-economic and political contexts, they can be used to demonstrate crucial aspects that may influence the outcome of future relocation policies. Using analogies of the past may therefore be useful as a diagnostic and predictive tool for future planning. In the case of Reef Islands, there is much to be learned from the historical process of resettlement in southern parts of Santa Cruz / Ndeni Island and the current situation for permanent migrants in these places, as elsewhere in Solomon Islands (E.g. Birk, 2011). One of the essential issues about migration and resettlement in Solomon Islands is associated with customary land tenure and access to natural resources. Customary entitlements are strongly embedded in the rules and norms of every community, and are often complex to formalize, register and map. In terms of policymaking, more attention needs to be directed towards the development of frameworks for managing potential relocations, including resettlement strategies that aim to secure peoples rights and livelihoods. In moving toward more coherent frameworks, the lessons of the past will be useful to illuminate the pitfalls in programs that failed.

Relocation within community boundaries and within islands is currently being used in many communities as a response to erosion or storm surges. This type of relocation is different from inter-island relocation, since it involves local arrangements (e.g. land tenure) and rarely has direct impact on livelihoods. Hence, this strategy will continue to be used, also in response to climate change and sea level rise – in so far that buildings can be moved further inland.

Lastly, it has been widely debated if relocation or forced migration should be regarded as adaptation. Some say it needs to be considered as a *failure to adapt*, while others point out that it represents the *limits to adaptation* or should be regarded as an *impact of climate change*. As previously stated in this report, adaptation to climate change is context specific to people and places, therefore it remains important to judge what is necessary in each case and what are the priorities of local people. Human mobility is an inherent feature of atoll island livelihoods, including urban migration and resettlement in neighboring islands. Thus, various forms of relocation have taken place over the years and will probably continue to do so. Causes and drivers of population movement are often many and complex, and vary according to changes in socio-economic and environmental circumstances. Relocation or planned migration is not likely to be driven by climate change alone, since people constantly maneuver between barriers and opportunities to secure their needs and wants. Admittedly, based on projections of climate change and sea level rise it is possible that the ability of atoll ecosystems to sustain human habitation will be compromised in the long term. However, in the case of Reef Islands the political discourse of 'sinking' or 'collapsing' island ecosystems is highly hypothetical, and in the coming years and decades there are more immediate problems to attend to.

<u>Disaster risk reduction</u>

In recent years, the advance in national and provincial disaster management has had a positive effect in many parts of Solomon Islands. The establishment of strategically located stocks of rice and medicine implies that the reaction time in response to extreme events and humanitarian disasters has been reduced considerably, at least in some cases and particularly since the disastrous tsunami incident in 2007. Nevertheless, within the field of disaster management there has been an emphasis on relief and recovery processes that prioritize a return to normalcy. While this strategy may be valuable in response to rapid onset hazards, the approach is inadequately shaped to deal with future risks. The return to normalcy will only last until the next hazard occurs, unless communities take precautionary measures in form of risk management. Often this is not the case, since people quickly surpres disastrous incidents and go on with the daily activities. Thus, reactive response activities need to include a planning and risk reduction phase, involving anticipatory or proactive management – an adaptation component. An important task for the relevant institutions and stakeholders is to come with a working plan or disaster risk reduction framework by which they may assist in enhancing local community resilience. This may include awareness campaigns or solid adaptive measures, and a phone number or formula do not suffice

The latter refers to findings in Reef Islands, where a local man was put in charge of registration of damages in response to hazards, which would subsequently be reported to Solomon Islands Red Cross. For this purpose the man had received basic instructions on how to fill out a template form and submit the information. Despite any good intentions of showing trust in local people and supporting capacity building, this approach to disaster risk management will not suffice on a permanent basis.

Currently, work is being done to improve these standards through an integration of the national disaster management office (NDMO) and the national climate change division (CCD). This work needs continued encouragement by national policy-makers, as well as economic and technical support from the government and donors.

<u>Mainstreaming adaptation</u>

Development organizations working in Solomon Islands have increasingly shown interest in CC issues, but there is still large potential for mainstreaming climate change adaptation into development plans and policies at a national and local scale. It could be argued that climate change is not the most pressing challenge facing the Reef Islanders. Hence, other development objectives may be given higher priority than adaptation. This includes projects which may assist in creating local jobs and income opportunities, such as the stimulation of commercial agriculture and fishery. The tourist business is another relatively unexplored opportunity in Reef Islands and the rest of Temotu, but this has to be integrated with the development of infrastructure, food security, conservation etc. The infrastructure in Solomon Islands is in dire need of improvement, both in relation to transport, communication and buildings. As previously mentioned, remote communities like the ones in Reef Islands are strongly disadvantaged by the islands geographical characteristics and location, and the associated costs of accessing markets, hospitals, and jobs. In terms of **communication**, this has been slightly improved in Reef Islands by the erection of a mobile telephone mast in Lomlom island. However, at the time of visit, the use of mobile phones in Reef Islands was restricted to certain areas in the Eastern Islands (Lomlom, Fenualoa, Ngadeli, Pidgin Island) and involved high expenditures on purchase of handset and credit. Contact between the islands and to the mainland mainly goes through two-way radio or is delivered by visitors/migrants. Communication technologies are evolving rapidly, and if promoted in sound ways, they may act to reduce the insulation of remote island populations. Another important aspect of infrastructure includes **transport** of commodities and people, where there is still need for the improvement of reliable and save connections. The importance of cargo and ferry transport has frequently been highlighted by local stakeholders and policy-makers, and some improvements have been made. Still, the development of the transport sector is highly relevant in order to reduce the disadvantages of remote atoll communities, including fair government regulation and adjustments of the frequency of arrivals, ticket prices, safety standards etc. Government subsidies or development funding may be necessary to achieve such goals. Lastly, there have been several calls for the improvement of public **buildings** and constructions, including medical clinics, schools, market buildings, workshops, jetty's etc, water tanks, wells etc. In most cases, the principal responsibility of renewal and maintenance lies with the government, but local stakeholders also play an important role. It would be feasible to create local incentives for care and maintenance, since the continued utility is in the interest of local users. Except from economic incentives, local advance in these areas could involve local capacity building (education/training), awareness campaigns etc. The above mentioned issues are often interrelated, which implies that development planning and implementation has to take a holistic approach. As example, the long standing project proposal (since 1970s) aiming at the establishment of a local air field in Reef Islands has been delayed for many reasons, which are not only related to economic costs. Despite the potential benefits represented by the opportunity of accessing Reef Islands by plane, there are many barriers to overcome. Problems related to location, land, entitlements, power and politics, planning and maintenance are complex obstacles both at a local, regional and national level. Altogether, the 'airfield' is just an example of social-economic dynamics leaving rural development in limbo. The slow progress of local development has resulted in increased disparity within the country, which people in Reef Islands endure by finding alternative ways of accessing financial means to attain higher local living standards. As elsewhere in rural Solomon Islands, households increasingly rely on urban migration and remittances.

Many development initiatives are closely related to the above listed adaptation options, and therefore the 'climate' dimension could be integrated as an extra element in many local development projects. In this connection, there are some issues that need to be attended to in relation to project time frames, financial support and technical knowledge. As an example, the long term projections and scenarios of climate change do not fit well into short term development project schedules; often running on 3-5 years budget periods. The success or failure of such projects may be evaluated immediately after termination of the funding, at a time when the long term effects is still difficult to estimate. A proposed way to avoid these uncertainties is to ensure that all components of the project are aimed at responding to immediate needs and wants as defined by the recipients. This approach to the prioritization of adaptation options is commonly described as 'no regret' solutions. However, there is a tendency to mistake this concept with simple economic cost-benefit calculation, which may result in national policies that disfavor those already vulnerable and marginalized.

The dilemma about cost-efficient versus fair and equal adaptation needs to be considered carefully before climate change is mainstreamed into existing development policies. The balance between cost-efficiency and fairness can be rather difficult, and the prioritization of one area over another is likely to create both winners and losers – i.e. the implementation of certain adaptation projects in one community, could mean hazard for another community where this option is absent. Hence, a huge challenge for decision-makers in Solomon Islands is to identify a criteria for an equal and fair distribution of development and adaptation benefits

<u>Maladaptation</u>
In line with previous suggestions, there are certain 'maladaptive' or unsound practices which could be avoided. Unsustainable management or overexploitation of natural resources, including mono-cropping that reduces soil fertility; the removal of sand from village shores for the decoration of communal grounds and graveyards; unregulated harvest of marine species (beche de mer, shark fins etc.) may act to deplete resources and exacerbated local environmental change. Likewise, the reliance of fruits or certain root crops at certain times a year may increase the overall sensitivity to climate variability. Therefore, there is a general need to create an awareness of sustainable management practices and widen the diversity of the local production systems at all times a year. This requires strong leadership and collaboration within and between communities in terms of planning, exchange of knowledge, trading, investments, test areas etc. These are just a few examples to which more could be added, though some are more culturally controversial. Admittedly, the identification of such 'maladaptive' practices can interfere with customary beliefs and culturally important activities. Hence, such options sometimes lie outside the range of acceptable adaptations.

Concluding remarks: the way forward

In Solomon Islands, an accepted view is that atoll islands in Solomon Islands are shrinking and sinking due to climate change and sea level rise. Based on field work observations and literature review, this report argues that people in the Reef Islands are <u>not</u> at particular risk of loosing their islands any time soon. Admittedly, based on projections of climate change and sea level rise it is possible that the ability of atoll ecosystems to sustain human habitation will be compromised in the long term. However, this cannot be translated as 'urgent risks of collapse', which some commentators have a tendency of doing.

It is likely that climate change and sea level rise will act to exacerbate the environmental stressors impacting on local production systems and infrastructure. Hence, there are good reasons for addressing the options of adaptation. However, climate change is not the only challenge. Adaptation is an ongoing process, involving a wide range of activities and measures, which cannot be solely aimed at reducing the adverse effects of climate related changes. Despite the brief discussions in this report, the linkages between climate adaptation, disaster management, and development in Solomon Islands remain relatively unexplored, but represent a cross-field which needs far more attention.

In Solomon Islands, the Climate Change Division (CCD) under the Ministry of Environment, Meteorology and Conservation is working hard to address these issues in an adequate manner. As an illustration, this report results from collaboration between the author and CCD officers, and was compiled on requests from the CCD. It will be exciting to follow the outcome of and work beyond the present project activities (Pacific Adaptation to Climate Change – PACC) and how they will assist in strengthening resilience in low-lying islands and atolls, i.e. Reef Islands, Ontong Java and Sikaiana.

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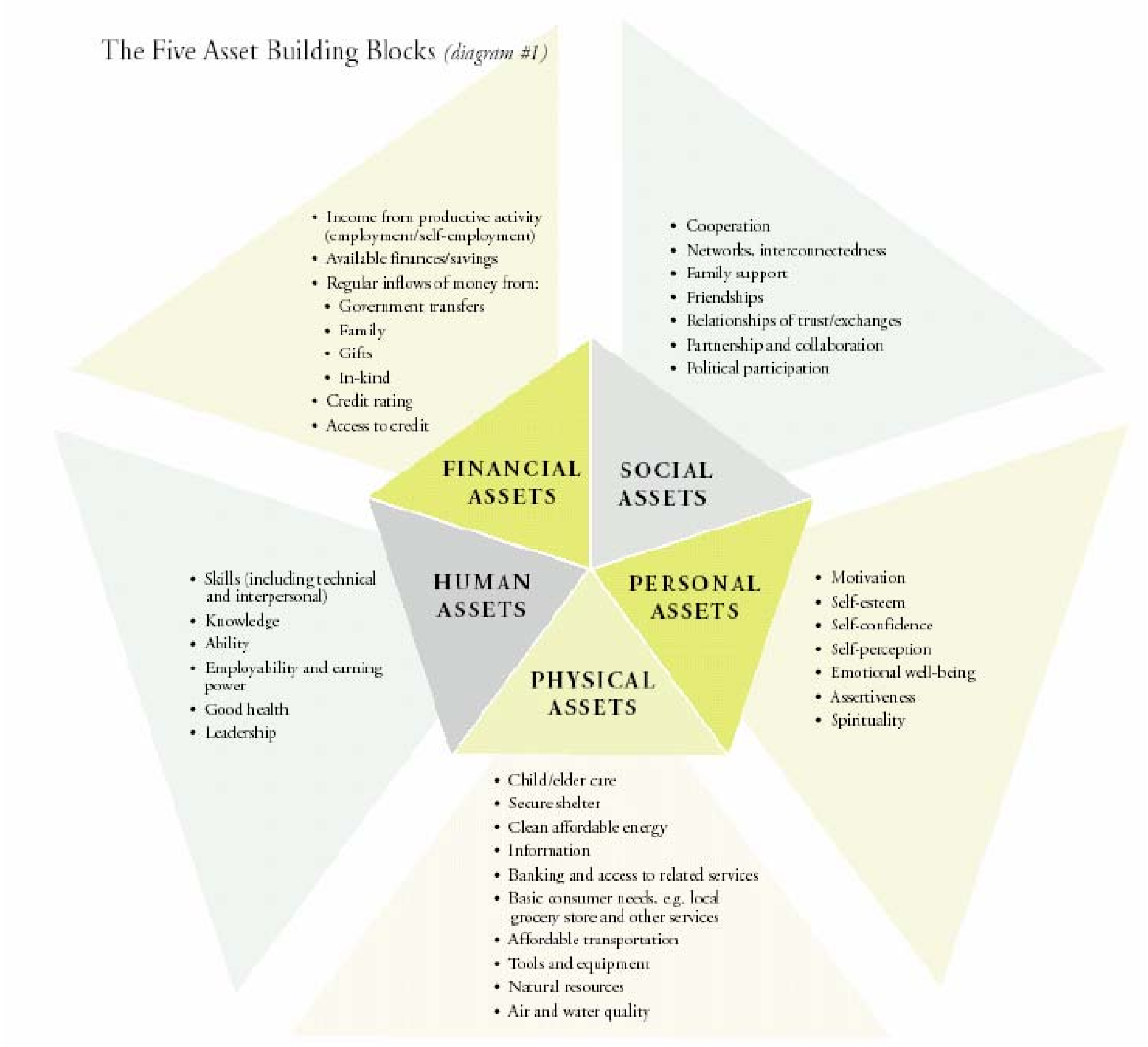
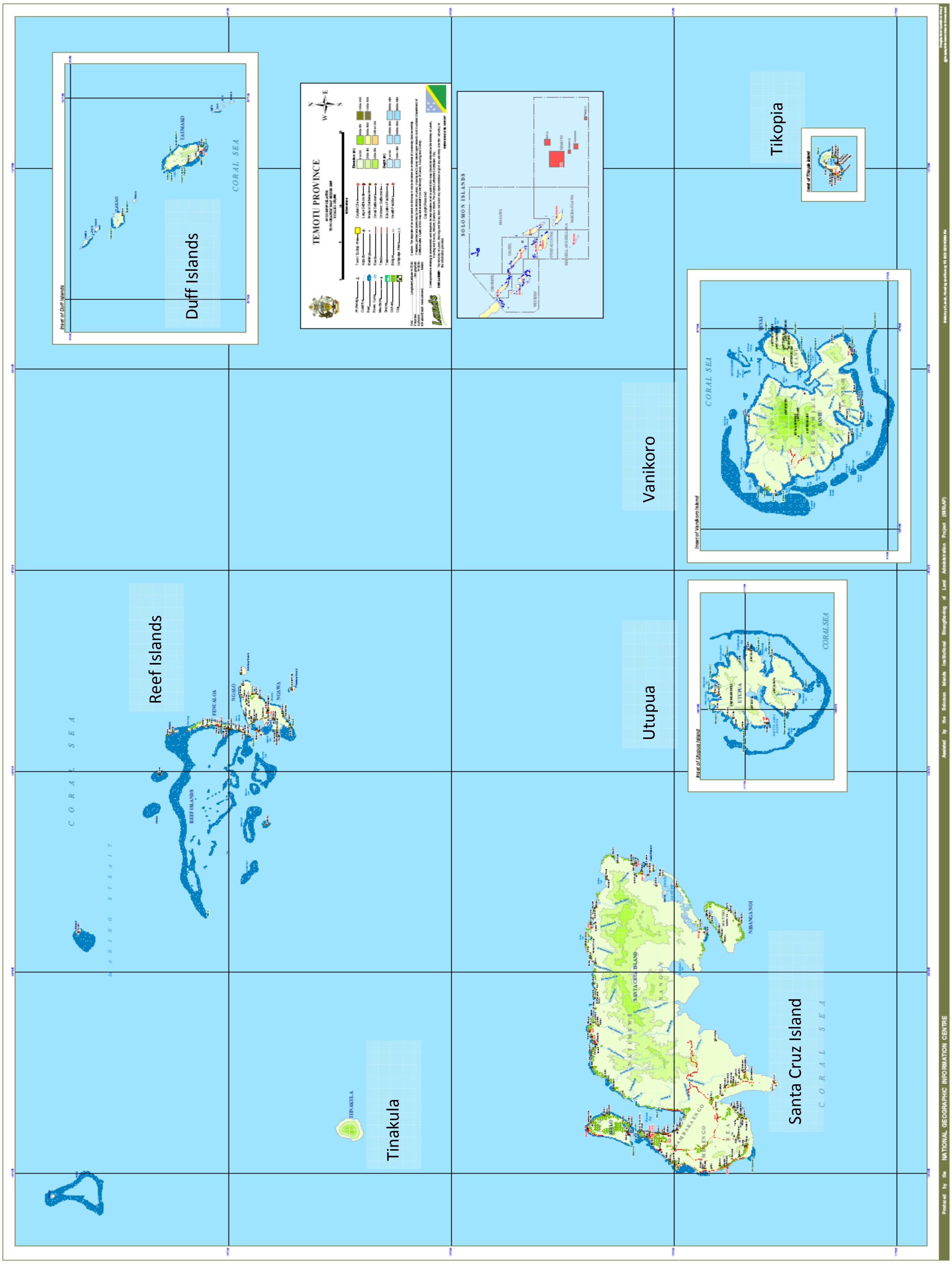
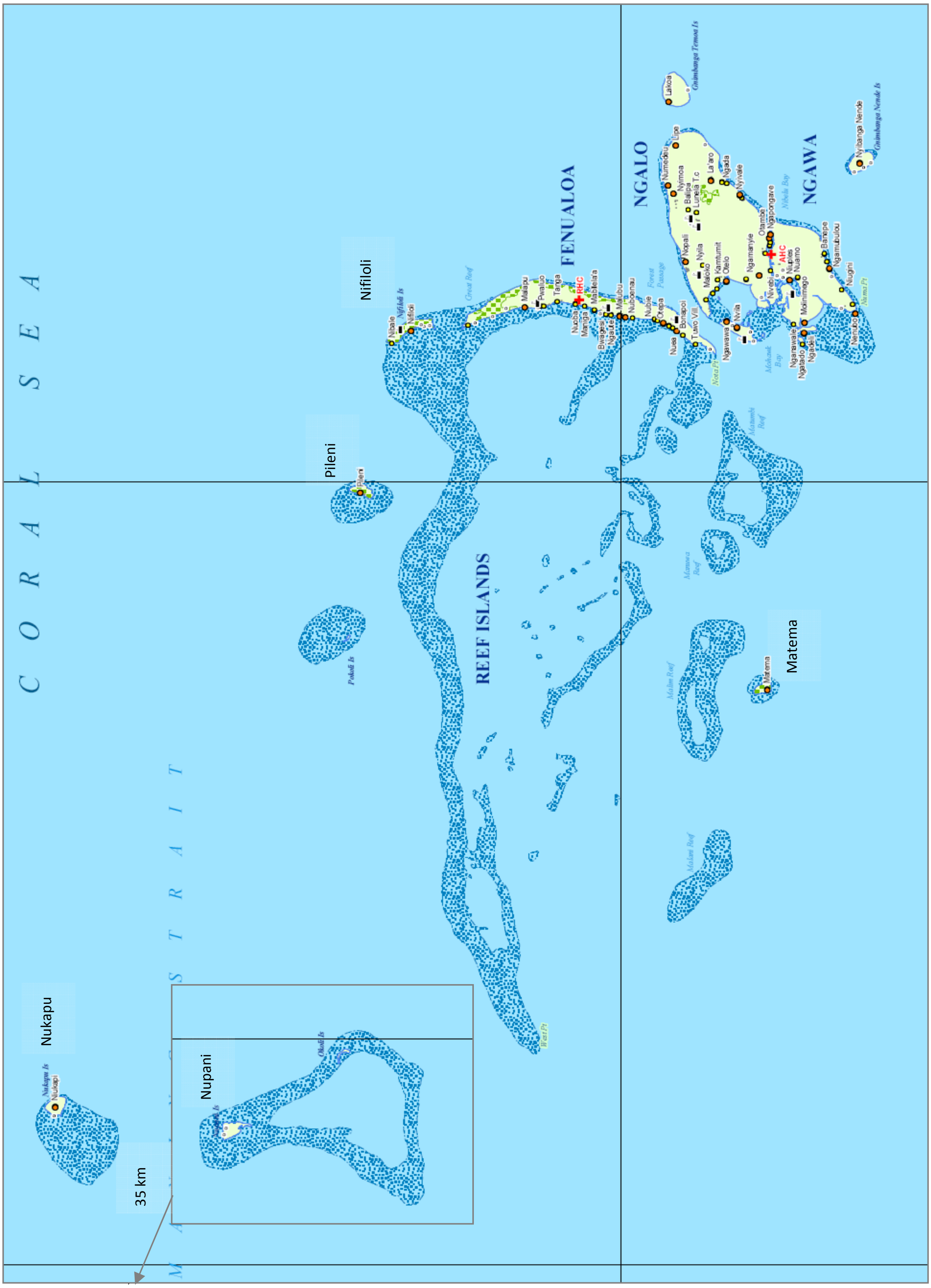
Annex 1: The five asset blocks of the SLA

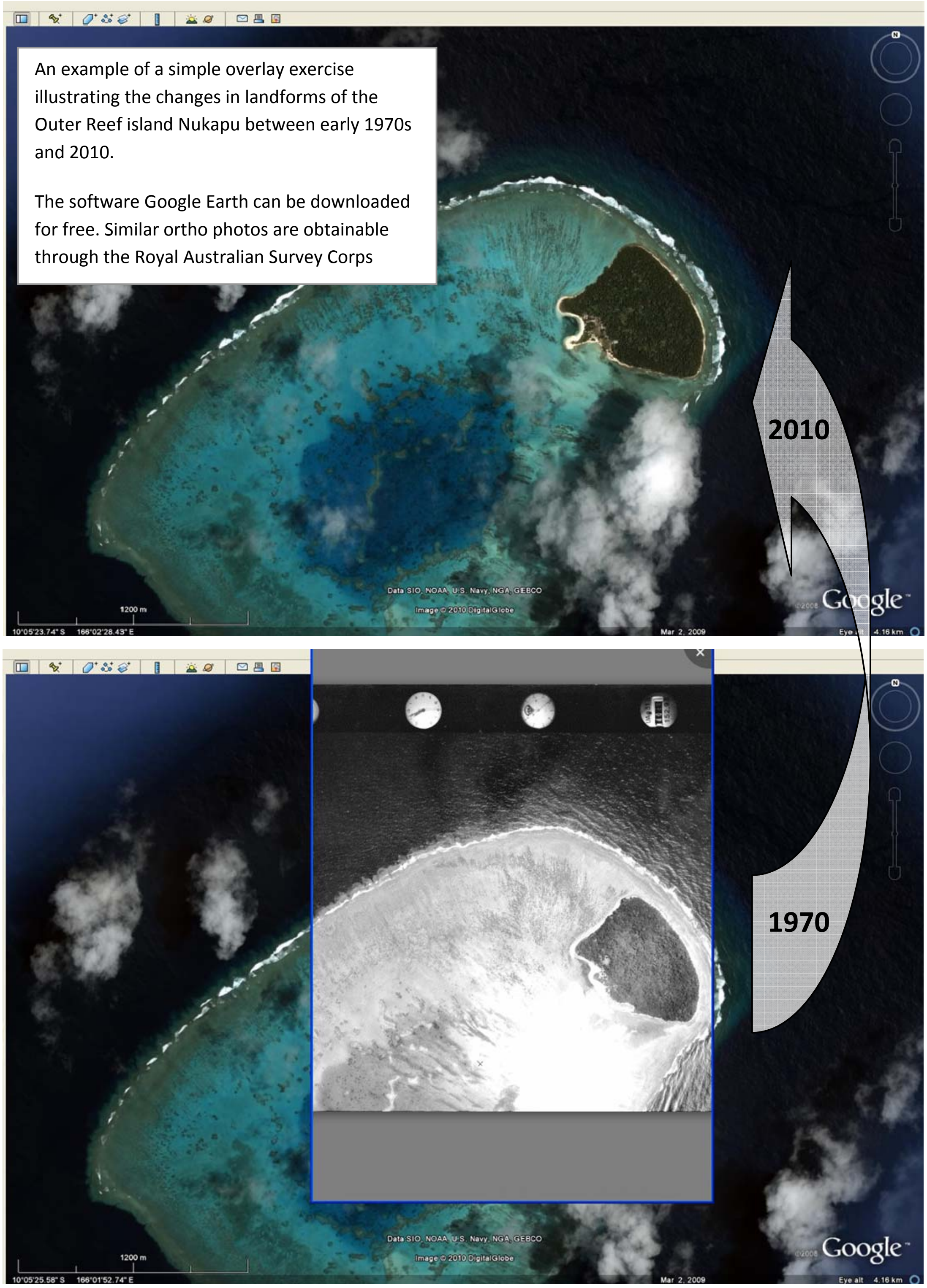


Annex 2: Maps showing Temotu Province and the Reef Islands




C O R A L   S E A
REEF ISLANDS
FENUALOA
NGALO
NGAWA
Nifiloli
Pileni
Matema
Nukapu
Nupani
35 km
RHC
AHC

Annex 3: Temporal aspects of erosion and sea level rise



Annex 4: Illustrative comparison of strategies for participation

The figure refers to the table shown in section 3.3.1.

Low Participation	High Participation	Overcoming Participation Weaknesses
Participation only up to level 3 of table 3: i.e. listening, giving information and consultation only Few groups involved	Participation up to Level 5 of Table 3; i.e. also participation in agenda-setting, analysis and consensus Many groups involved	
PROS: ■ Low costs of participation ■ Few local expectations raised ■ Relatively quick ■ Technical detail ■ Technical rigour ■ Clear leadership of process ■ Strategy management easy ■ Gives strong directions ■ High involvement at top ■ Few conflicts during preparation ■ Understood by donors ■ Can be quick political impact ■ Done with routine procedures	CONS: ■ Higher costs ■ Can raise expectations ■ Slower (depends on systems used) ■ Less technical detail ■ Trustworthiness problems ■ Shared/changing leadership ■ Complex strategy management ■ Directions more devolved ■ Less control at top ■ Many conflicts exposed ■ Difficult for donor cycles ■ Political impact slower/surer ■ Incentives needed to participate ■ Participation fatigue in actors ■ Participation skills needed	■ Share costs among actors ■ Phase participation process ■ Quick first iteration; then deeper ■ Bring in expertise (in Participatory Inquiry) ■ Framework for judging ■ Institutionalise this ■ Hire personnel with experience ■ More monitoring and coordination ■ Strengthen top-bottom links ■ Deal with them in phases ■ Focus donors; flagship projects ■ Major, phased strategy events ■ Incentives early in participation plan ■ Only appropriate participation ■ Hire and train early
CONS: ■ Limited understand by public ■ Limited "energy source" for ideas ■ Limited commitment to implement ■ Have to "sell" to implementers ■ Undue influence of external experts ■ High (cross-sectoral) technical skills needed ■ Much relevant information missing ■ Analysis/policy may not reflect reality ■ Weak processes for sustainable development trade-offs ■ Judgement of a few "experts" only ■ Only government implements	PROS: ■ Strong public understanding ■ Release much energy for ideas/inputs ■ Strong implementation commitment ■ Strategy not a surprise to actors ■ External experts used appropriately ■ Does not depend on high science; participation offers analogues ■ Uncovers information that matters ■ Analysis/policy checked with reality ■ Strong processes result ■ Gives best informed judgement ■ Much more local/private implementation	

Adopted from Bass, S *et al*, 1995